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INDEPENDENT RESEARCH AND INDEPENDENT EXPLORATORY DEVELOPMENT: ANNUAL REPORT

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AN ACTIVITY OF THE NAVAL MATERIAL COMMAND

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This report is submitted in response to NAVMATINST 3920.3B of 12 June 1972. It consists of descriptions in layman's terms of nine selected Independent Research and Independent Exploratory Development projects. These descriptions are followed by a list of all the projects active or terminated since the last annual report and of the publications resulting from them.

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13. ABSTRACT

This report describes the Independent Research and Independent Exploratory Development program at the Naval Undersea Center during fiscal year 1973. It consists of brief articles on nine selected projects together with a listing of all projects active or terminated since the last annual report and the publications resulting from them. The articles describe the following work: determination of the solubility of hydrogen in seawater; development of a noise cancelling technique that reduces interference in the signal channels of existing sonar systems; studies in the design and application of the S^3 semisubmerged ship; development of self-contained water-inflated sonar array structures that can be deployed without the assistance of divers; development of a high speed sonar system that enables high performance surface craft and helicopters to track fast nuclear submarines; development of viewports for optical systems aboard deep-diving submersibles; development of a technique for forming visual images by processing ultrasonic sound scattered by objects in the water; efforts to incorporate glass optic fibers into cables of useful length; and upgrading of the SCAT submersible as well as development of an entirely new submersible, ELECTRIC SNOOPY.

I

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Independent research						
Independent exploratory development						
Chemical oceanography						
Solubility						
Hydrogen						
Sonar self noise						
Noise reduction						
Sonar detection						
S^3 semisubmerged ship						
Sonar arrays						
Antisubmarine warfare						
High speed sonar						
Optical glass						
Deep submergence						
Glass fibers						
Rayleigh waves						
Ultrasonic radiation						
Optical communication						
Deep ocean vehicles						
Underwater cables						
Unmanned submersibles						

II

contents

introduction

This report summarizes the Independent Research and Independent Exploratory Development Program at the Naval Undersea Center for fiscal year 1973. This program enables NUC scientists and engineers to pursue novel solutions to clearly defined Navy problems. Concurrently, it encourages the development of the scientific and technical expertise the Navy will need to meet future challenges. The range of work undertaken is evident in the nine projects described.

The research reported in the article on the solubility of hydrogen in seawater exemplifies work aimed at determining how gas bubbles in seawater affect the performance of various Navy systems.

A means of significantly improving the performance of existing sonar systems is described in the article on adaptive noise cancelling.

The article on the S^3 semisubmerged ship describes studies in the design of this new vessel to meet potential Navy requirements.

Self-contained sonar array structures which can be deployed without the aid of divers are described in the article on water-inflated array structures.

The article on high speed towed sonar describes the development of a sonar system which enables high performance surface ships or helicopters to combat effectively fast nuclear submarines.

The development of viewports for optical systems aboard deep-diving submersibles is described in the article on glass and ceramic window-flange assemblies. These assemblies permit the use of television or photographic systems at great depths because they experience little deformation under hydrostatic pressure and continue to transmit undistorted optical images.

The article on ultrasonic imaging describes how visual images can be formed by processing ultrasonic sound scattered by objects in the water. This technique will permit divers and operators of submersibles to "see" even in turbid water.

Efforts to incorporate glass optic fibers into cables of useful length are described in the article on fiber optic cables.

The report concludes with an article describing recent work on small, unmanned submersibles including upgrading of the SCAT vehicle and development of an entirely new submerisble, ELECTRIC SNOOPY.

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selected independent research projects

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solubility of hydrogen in seawater

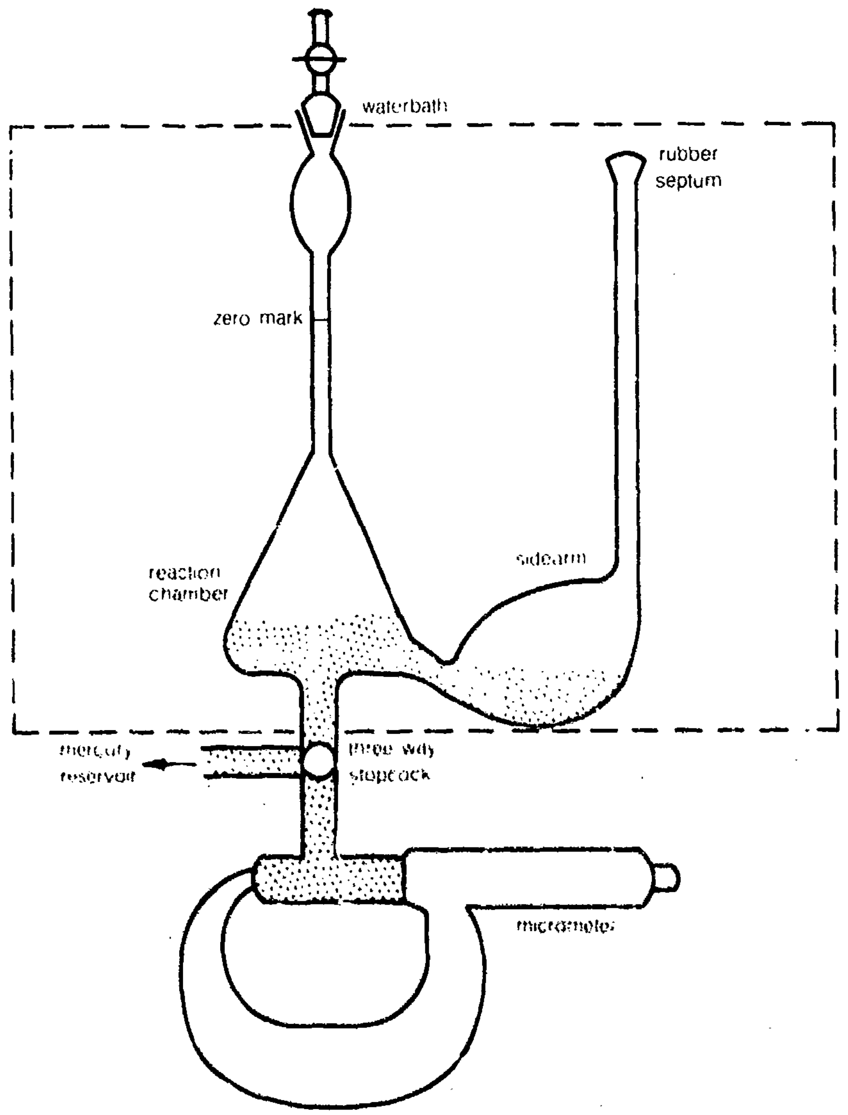
As a part of NUC's research in chemical oceanography a program was established to study the behavior of gas bubbles in seawater. This subject is of general interest to the Navy since bubbles can be formed by the mechanical action of propellor screws or introduced into the marine environment by undersea vehicles, habitats, torpedoes, or divers. The manner in which these bubbles behave once introduced into the sea has an important bearing on the operation and design of various Navy systems.

A gas which is sometimes introduced into the sea by Navy systems is hydrogen. The ultimate fate of hydrogen gas bubbles depends upon the rate at which the gas dissolves. This rate is a function of the diffusion constant of the gas, its solubility, and vapor pressures in both the gas and water phases. Thus, one of the fundamental parameters which determines the dissolution rate of a gas is its solubility. For hydrogen gas this parameter for seawater has, heretofore, not been known.

During the past year solubility coefficients for hydrogen were measured at a pressure of one atmosphere and at various temperatures in distilled water and in seawater at three salinities. The measurements were made by a microgasometric method using the absorption apparatus shown in figure 1. This method was selected because of its simplicity and accuracy.

The absorption apparatus was placed in a constant temperature bath which was regulated to 0.01°C; the temperature of the measurement room was regulated to within 2°C. Degassed water was introduced into the sidearm and a known volume of pure hydrogen gas was introduced into the reaction chamber. The two were initially kept separate by mercury in the bottom of the reaction chamber and side arm. Degassed water was then transferred to the reaction

Figure 1. Absorption apparatus for measurement of hydrogen gas solubilities.



chamber by tilting the apparatus. The vessel was shaken vigorously to equilibrate the gas and water; care was taken to avoid entrapment of bubbles and supersaturation. Equilibration was achieved within 5 to 10 minutes and was more rapid at higher temperatures and in distilled water than in seawater. The solution was allowed to equilibrate for 30 minutes in order to ensure complete mixing. Volumes of the gas and the water remaining were determined by means of the micrometer and the solubilities were calculated from the measured volumes. Ten replicate measurements were made for each temperature and salinity pair; the standard deviations ranged from 0.2 to 0.5 percent.

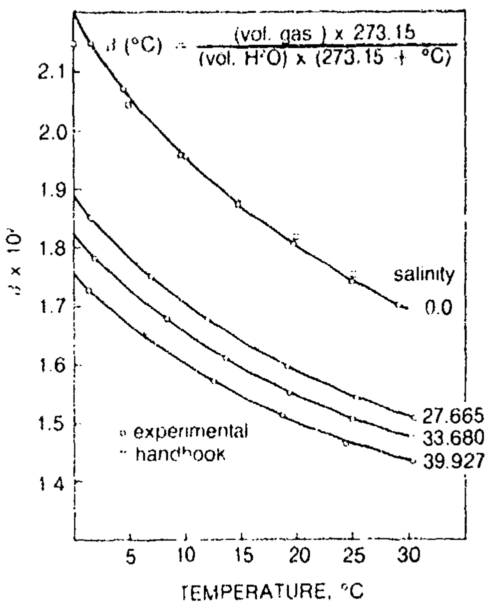


Figure 2. Bunsen solubility coefficients derived from solubilities of hydrogen measured in distilled water and in seawater at three salinities.

The measured solubilities were converted to Bunsen solubility coefficients, β, which is defined as the volume of gas (at 0°C and one atmosphere of pressure) absorbed in a unit volume of water at a given temperature. The results are shown in figure 2. The coefficients for distilled water agree well with handbook values which were originally reported about 70 years ago.

Bunsen solubility coefficients in the temperature range -2 to 31°C and salinity range of 0 to 40 parts per thousand were calculated from a six-term empirical equation describing solubility as a function of salinity and temperature. A digital computer program was written to fit the solubility data to the equation by the method of least squares. Coefficients for salinities 31 to 40 parts per thousand are shown in table 1.

DEGREES CELSIUS	SALINITY PARTS PER THOUSAND									
	31	32	33	34	35	36	37	38	39	40
-2	.018921	.018816	.018712	.018609	.018506	.018404	.018302	.018201	.018101	.018001
-1	.018705	.018602	.018501	.018399	.018299	.018199	.018099	.018000	.017902	.017803
0	.018497	.018397	.018297	.018198	.018099	.018001	.017903	.017805	.017710	.017614
1	.018297	.018199	.018101	.018004	.017907	.017811	.017715	.017620	.017525	.017431
2	.018104	.018008	.017912	.017817	.017722	.017628	.017534	.017440	.017348	.017255
3	.017919	.017825	.017731	.017637	.017544	.017451	.017359	.017268	.017177	.017086
4	.017741	.017648	.017556	.017464	.017373	.017282	.017191	.017101	.017012	.016923
5	.017569	.017478	.017387	.017297	.017208	.017119	.017030	.016942	.016854	.016767
6	.017404	.017314	.017225	.017137	.017049	.016961	.016874	.016788	.016702	.016616
7	.017245	.017157	.017070	.016983	.016896	.016810	.016725	.016640	.016555	.016471
8	.017092	.017005	.016920	.016834	.016750	.016665	.016581	.016498	.016414	.016332
9	.016944	.016860	.016776	.016692	.016608	.016525	.016443	.016361	.016279	.016198
10	.016803	.016720	.016637	.016555	.016473	.016391	.016310	.016229	.016149	.016069
11	.016667	.016585	.016504	.016423	.016342	.016262	.016182	.016103	.016024	.015946
12	.016536	.016456	.016376	.016296	.016217	.016138	.016060	.015982	.015904	.015827
13	.016411	.016332	.016253	.016175	.016097	.016019	.015942	.015865	.015788	.015712
14	.016290	.016212	.016135	.016058	.015981	.015905	.015829	.015754	.015678	.015604
15	.016174	.016098	.016022	.015946	.015870	.015795	.015721	.015646	.015572	.015499
16	.016063	.015988	.015913	.015838	.015764	.015690	.015617	.015543	.015471	.015398
17	.015956	.015882	.015809	.015735	.015662	.015589	.015517	.015445	.015373	.015302
18	.015854	.015781	.015709	.015636	.015564	.015493	.015422	.015351	.015280	.015210
19	.015756	.015685	.015613	.015542	.015471	.015400	.015330	.015260	.015191	.015121
20	.015663	.015592	.015521	.015451	.015381	.015312	.015242	.015174	.015105	.015037
21	.015573	.015503	.015434	.015365	.015296	.015227	.015159	.015091	.015024	.014956
22	.015487	.015419	.015350	.015282	.015214	.015147	.015079	.015012	.014946	.014879
23	.015405	.015338	.015270	.015203	.015136	.015069	.015003	.014937	.014871	.014806
24	.015327	.015260	.015194	.015128	.015062	.014996	.014930	.014865	.014801	.014736
25	.015253	.015187	.015121	.015056	.014991	.014926	.014861	.014797	.014733	.014669
26	.015182	.015117	.015052	.014987	.014923	.014859	.014796	.014732	.014669	.014606
27	.015114	.015050	.014986	.014922	.014859	.014796	.014733	.014670	.014608	.014546
28	.015050	.014987	.014924	.014861	.014798	.014736	.014674	.014612	.014550	.014489
29	.014989	.014927	.014864	.014802	.014740	.014679	.014618	.014557	.014496	.014435
30	.014931	.014869	.014808	.014747	.014686	.014625	.014565	.014504	.014444	.014384
31	.014877	.014816	.014755	.014695	.014634	.014574	.014515	.014455	.014396	.014337

Figure 3. Bunsen solubility coefficients calculated from experimental data using an empirical equation

adaptive noise canceling

Sonar systems using hull-mounted or towed arrays are subject to interference from self-noise generated by the sonar platform or towing vessels. A new approach to reducing this interference was investigated at NUC during the past year. Adaptive noise canceling removes noise directly from the signal channel rather than trying to prevent it from corrupting the signal initially. A prototype noise canceler has been constructed and is currently being tested at NUC (figure 1). This device is based on the theory of adaptive systems and was made possible by the development of digital signal processing techniques. The noise canceler adapts directly to most existing sonar systems without modification to the array, beamforming, or signal processing. For this reason, it offers the potential for significant improvement in the performance of these systems at comparatively low cost and in significantly less time than is required by more conventional methods of attacking the problem.

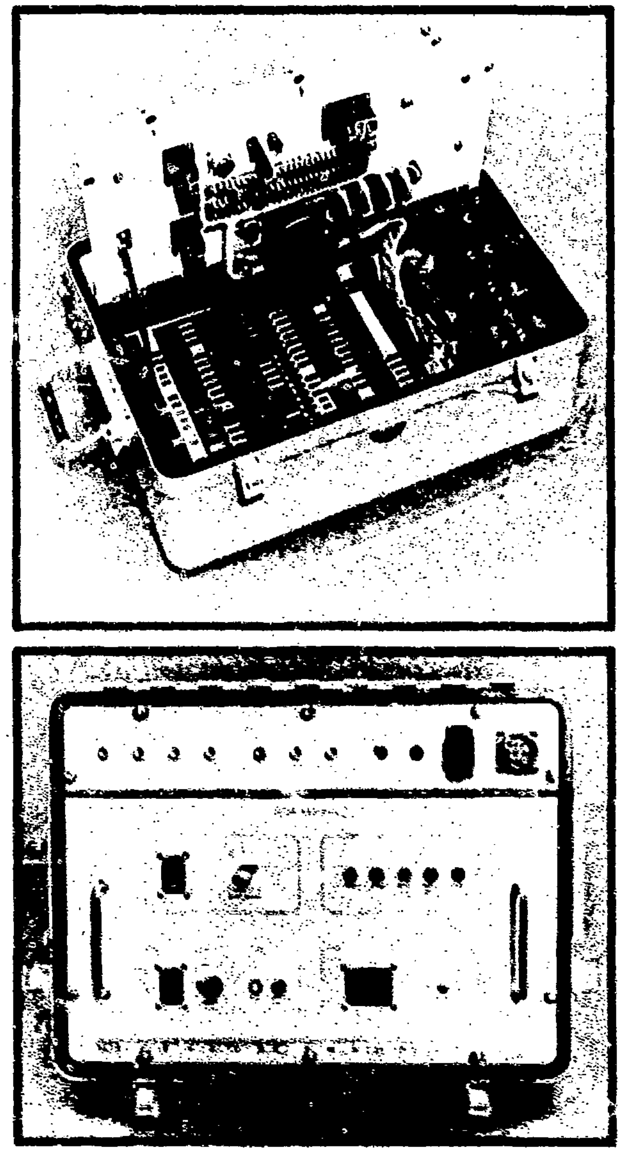
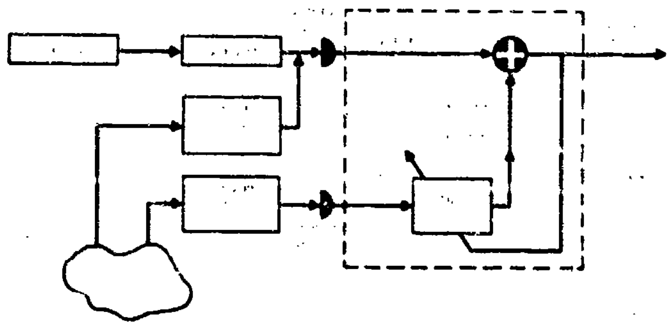


Figure 1 The NUC noise canceler.
The ruler shown in these photographs is 18 inches long

The noise canceler reduces noise in a signal channel by subtracting it out or canceling it. The noise canceling process is diagrammed in figure 2. Primary and reference inputs are accepted by the noise canceler. The primary input contains the signal to be detected together with the noise to be canceled. For a sonar system, the primary input is the output of one beam of the sonar. The reference input contains noise that is related to the noise in the primary input but contains little or no signal. Noise in the reference channel will be properly related to that in the primary channel if it comes from the same source or sources and is not badly distorted along the paths to the primary and reference sensors. Aboard ship, vibration sensors and input containing all harmonics of all the AC power generated on the ship are expected to provide satisfactory reference input. Inputs and outputs are analog but all internal processing is digital.

Figure 2. The noise canceling process.



Noise reaches the primary and reference sensors by different paths. The primary function of the noise canceler is to [illegible] the noise in the reference channel, correcting for differences between the primary and reference paths. This makes the noise at the filter output closely match that in the primary channel so that it will cancel the noise in the primary channel when it is subtracted from it.

The filtering is achieved by the adaptive filter, an electronic device with variable filter characteristics or transfer function. The transfer function of the filter is determined by continuous feedback from the output of the noise canceler and is thus constantly adapting to immediate conditions. The feedback is designed so that the filter adapts to the transfer function that minimizes the energy at the noise canceler output. Since the reference input is noise alone, virtually signal free, the output energy cannot be further reduced by the noise canceler once the noise has been canceled from the signal channel and no new noise added. If the signal and noise are statistically independent, the result is noise-free signal. To achieve this result the adaptive filter must be capable of correcting time delay or phase shift, frequency response, and attenuation differences between the two paths.

The adaptive noise canceler has proven effective in tests, with performance coinciding with theoretical understanding of the system. Figure 3 shows an example of narrowband noise canceling in which a group of lines is canceled. Under laboratory conditions, the attenuation of such lines is typically greater than 35 dB, and is limited only by the background quantizing noise from the analog-to-digital conversion at the input. Broadband noise is attenuated substantially less, not more than 20 dB. Under conditions where the broadband noise takes several paths from its source into the sonar, or comes in from different sources through different parts of the array, the noise canceler is ineffective. Since most practical self-noise problems have just such multipath or multisource conditions, the noise canceler is not expected to be effective against broadband self-noise in sonars. These same conditions do not affect the canceling of narrowband noise, however, since any number of sinusoidal components at the same frequency will add together to form a single sinusoid. The narrowband canceling is expected to be nearly as effective in the field as in the laboratory.

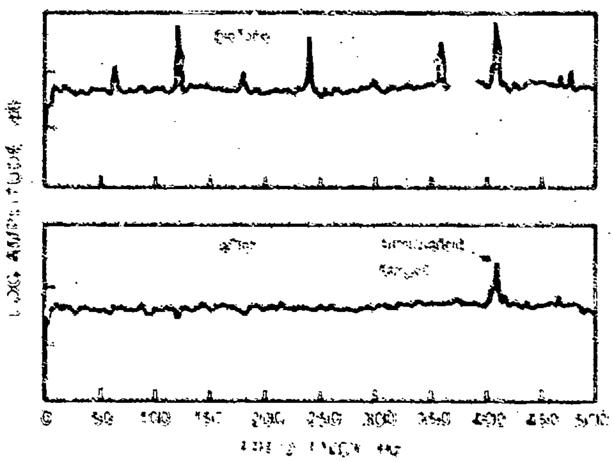


Figure 3
Example of noise canceling

system design concepts for future S³ ships

In 1968 T.G. Lang introduced a new type of semisubmerged ship called S³ (figure 1). Since that time, this unusual hull form has been the subject of intensive research at NUC. The design offers a means of building small 40-knot ships with large decks that remain nearly level in most sea state environments. Application studies indicate that this capability can revolutionize the design and use of surface-based systems. A 190-ton S³ platform has been constructed to demonstrate this potential (figure 2). The rapid advance of the S³ program at NUC has stimulated Navy-wide interest in so called SWATH ships, this acronym being derived from the phrase "small waterplane area twin hull." The

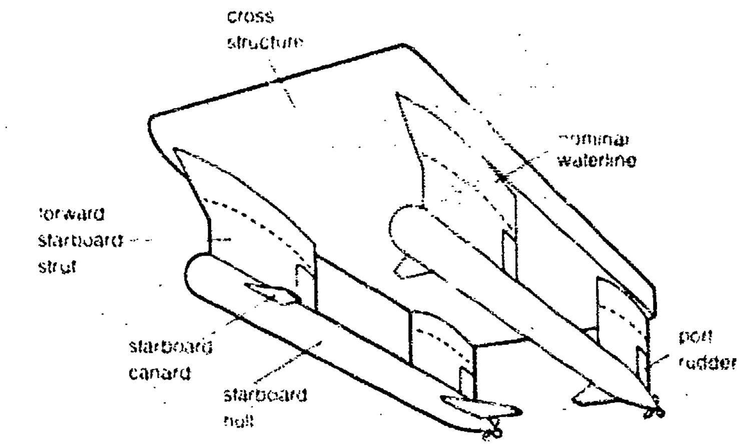


Figure 1   S³ semisubmerged ship concept

Naval Ship Systems Command is presently seeking funds to develop a 2800-ton SWATH ship having either one or two struts per side. NUC has been assigned responsibility for the various mission-related equipments that should be tested operationally on this ship.

During fiscal year 1973 internal funds were used to support two areas of study, with the general objective of determining how the advantages of the S³ concept can best serve the future needs of the Navy. The first study, entitled "Marine Corps Applications for S³ Semisubmerged Ships," has sought to identify ways in which S³ platforms can provide major seabasing support for Marine Corps operations. The second study, entitled "S³ Structural Design Study," has attempted to identify those aspects of structural design that have a critical impact on mission applications. The dependencies between structure and application proved to be so extensive that it became necessary to unite the two studies into a single effort. It has become evident that meaningful operational requirements for future S³ ships cannot be formulated until the relationships between operational uses and realizable design alternatives are understood in greater depth. It is of fundamental

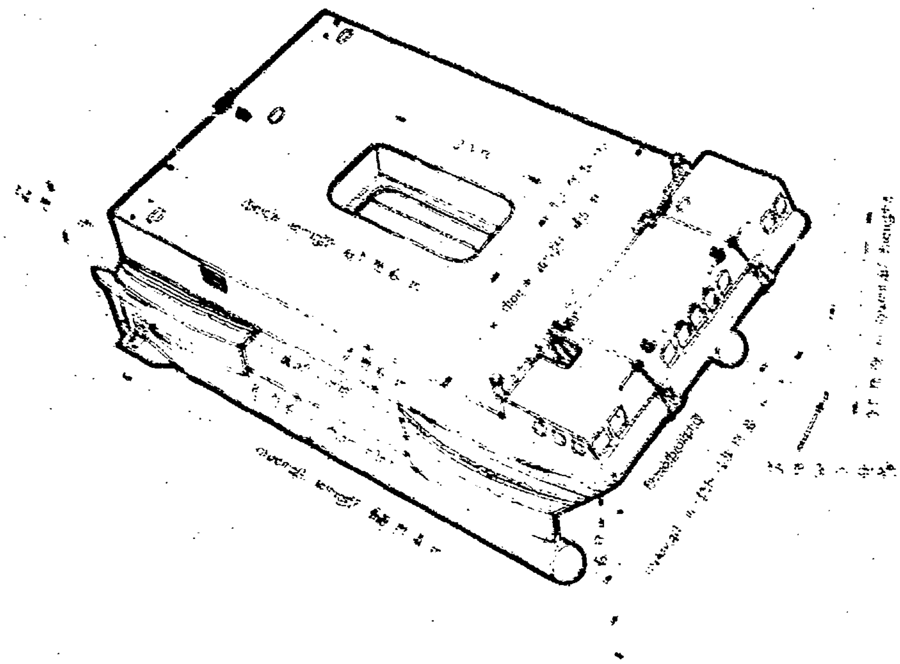


Figure 2   S³ design displacing 190 tons

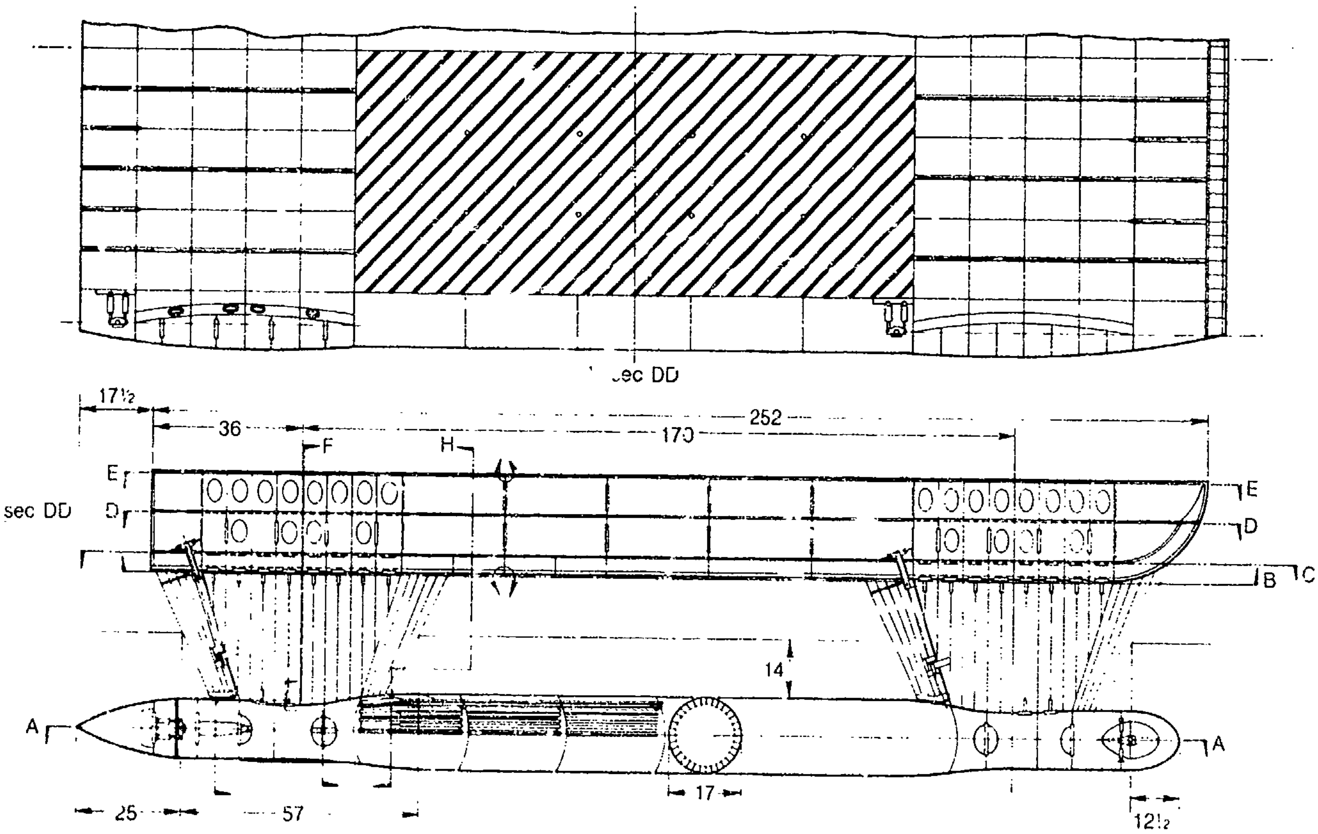


Figure 3. S^3 design displacing 3,000 tons. All dimensions shown are in feet.

importance that the first SWATH ship be designed and tested in a manner that will provide this understanding.

Some major advantages of the S^3 concept stem from the large deck areas and internal volumes that these designs provide. The subject studies indicate that maximum payload flexibility is achieved when the cross structure is two decks thick and no permanent ship structure rises above the main deck line. To achieve reasonable running ranges and payload capabilities, the weight of primary and secondary ship structure should not exceed 40 percent of full load displacement. As a consequence, ship structure will be aluminum with considerable emphasis on lightweight outfitting.

Figure 3 shows the largest S^3 geometry that appears practical when displacement is held constant at 3000 tons. Rudders are placed in all four struts to enhance maneuverability and yaw control. Hull diameter is increased between the fore and aft struts to decrease drag at cruise speeds. The cross hatching in 1/2 section D-D indicates the extent of the central portion of the cross structure that can be left open for modular payload installations. The volume surrounding these payload bays is sufficient to house all basic ship systems as well as some 200 people. The payload bays can then be outfitted alternatively for troop basing, medical support, V/STOL operations, missile firing, warehousing, small craft support, etc. In most of these applications, payload installations will rise above the main deck line.

Figure 4 shows the basic 3000-ton design outfitted as an operations platform for V/STOL aircraft. Modular facilities would provide organizational maintenance for 6 to 10 aircraft of a particular type equipped for close air support, vertical assault, surveillance, ASW, or some form of logistic support. The payload bays would house air personnel, maintenance facilities, and aircraft ordnance. Intermediate maintenance and permanent basing would be provided by sister ships equipped with lightweight hangars on the main deck.

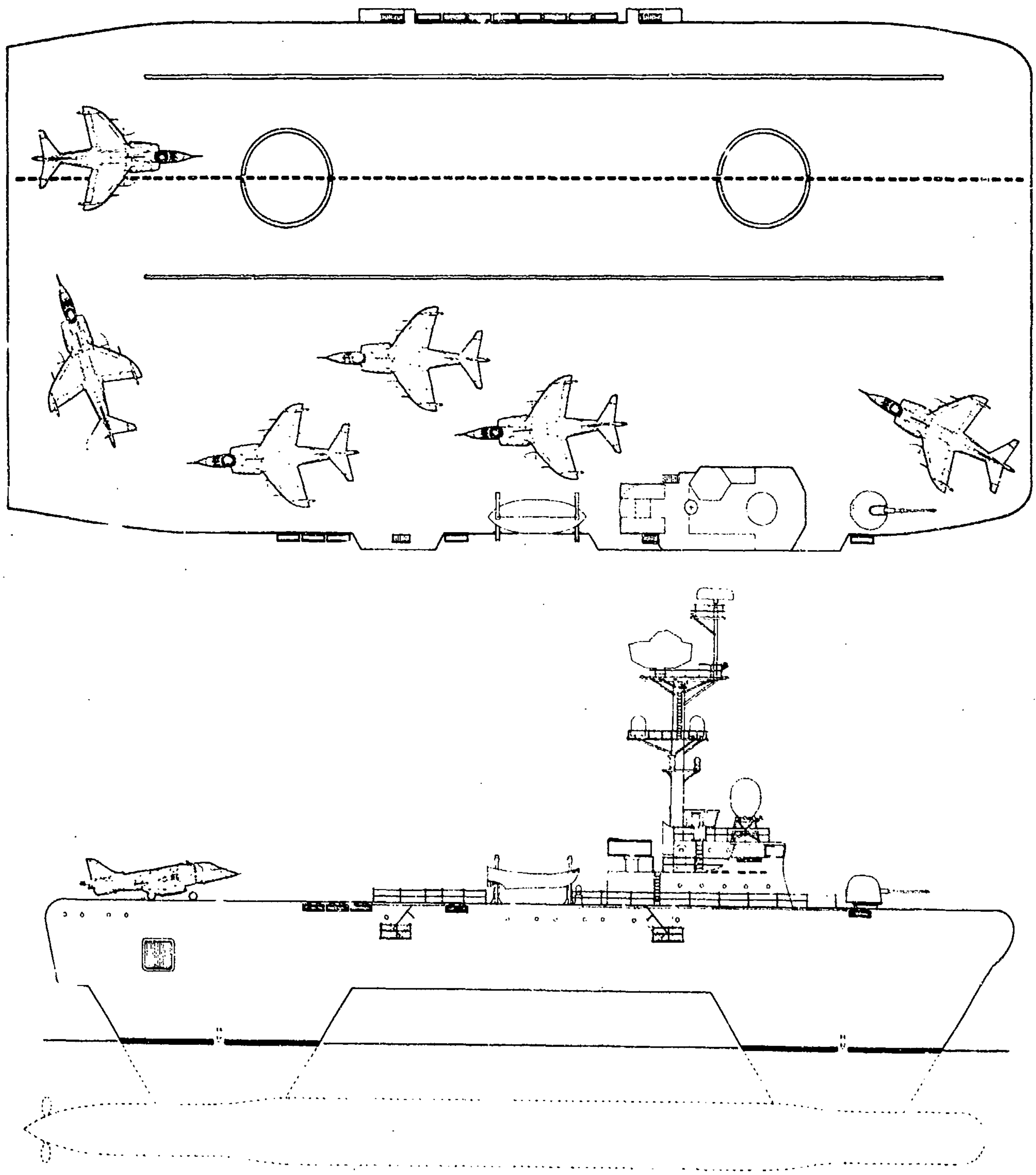


Figure 4. A 3,000-ton S^3 outfitted as a carrier for V/STOL aircraft.

The S³ concept provides a heretofore unavailable means of distributing seabase support for Marine Corps operations over large numbers of low value platforms sufficient in size and stability to make modular outfitting truly practical. The spacial distribution of capital resources is essential if the United States expects to operate effectively in coastal regions near secondary nations that have been armed with antisurface systems. Modular flexibility is essential because the nature of future coastal conflicts will not be fully known until many years after the basic support platforms have been designed.

Although the 3000-ton platforms envisioned here would not be costly compared to ships like the LHA, they would still become attractive targets in certain coastal situations. It appears likely that there will be a need for platforms of minimal size for deploying specific offensive and defensive systems in high risk environments. Figure 5 shows a 500-ton S³ design that appears well suited for such missions. This platform would have a top speed of 40 knots, a range of 1200 miles at 20 knots, and a payload capacity of 75 tons. It could be used effectively for surveillance, rocket bombardment, search and rescue operations, deployment of small search-and-destroy teams, or as a lily pad for close air support aircraft. A prototype development of such a platform would be well worth considering if funding for a larger SWATH ship is not obtained.

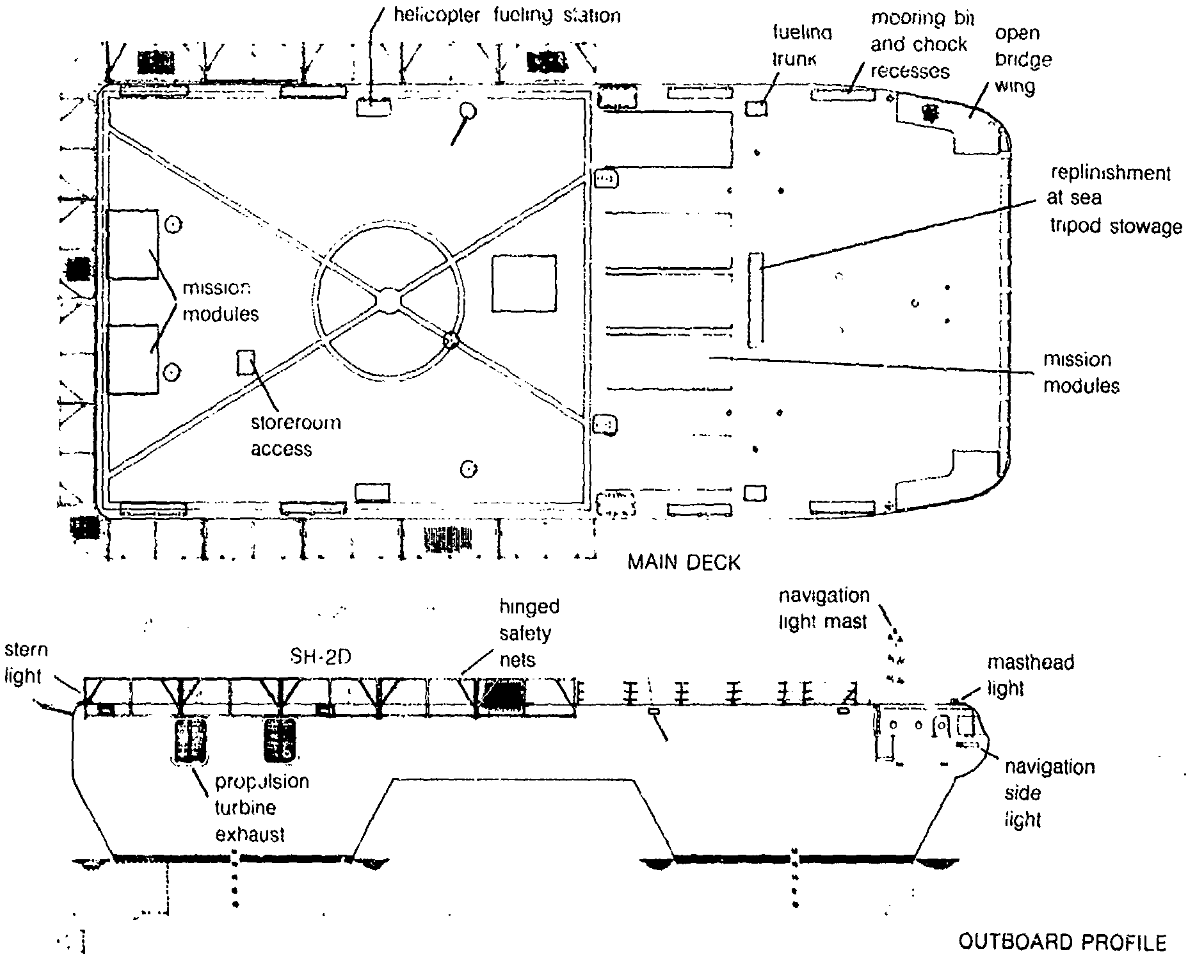


Figure 5. S³ of 500 tons designed to deploy modular surface systems in high risk environments.

selected independent exploratory development projects

water-inflated array structures

Collection of oceanographic data requires in many cases the location of sensors in some specified spatial arrangement.

This is particularly true in the study of physical and chemical parameters determining the propagation of underwater sound.

Sensors are generally held in a fixed spatial relationship with each other by a structure that derives its stability from the stiffness of its structural members or by a cable network that retains its original spatial orientations because of tension imposed on the cables by properly implaced anchors. Both technical approaches have been found to be successful in the past but both require many man-hours and a large number of ships for the

Figure 1. Fully Inflated triangular array structure.

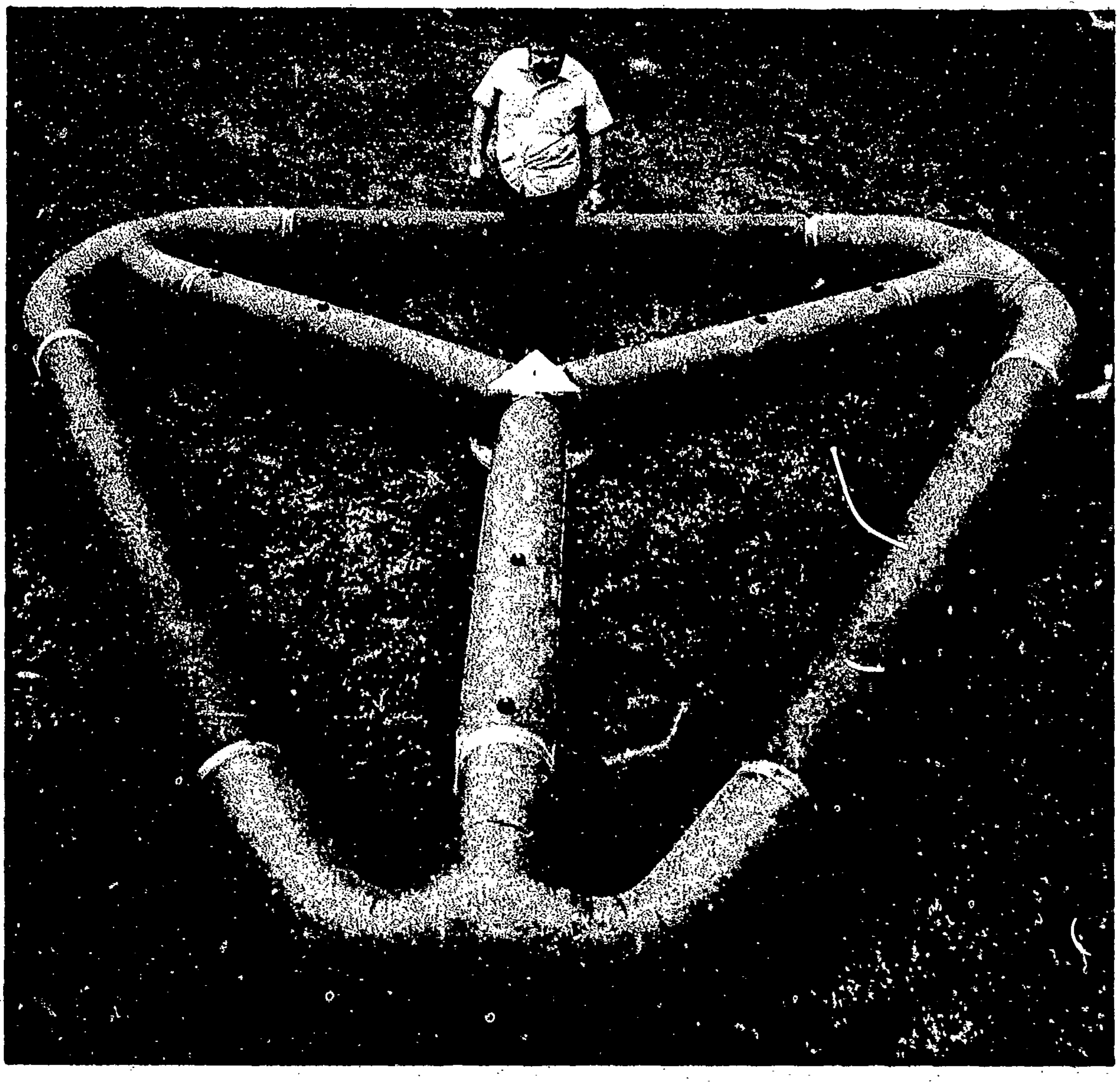


Figure 2. Partially inflated circular array structure.

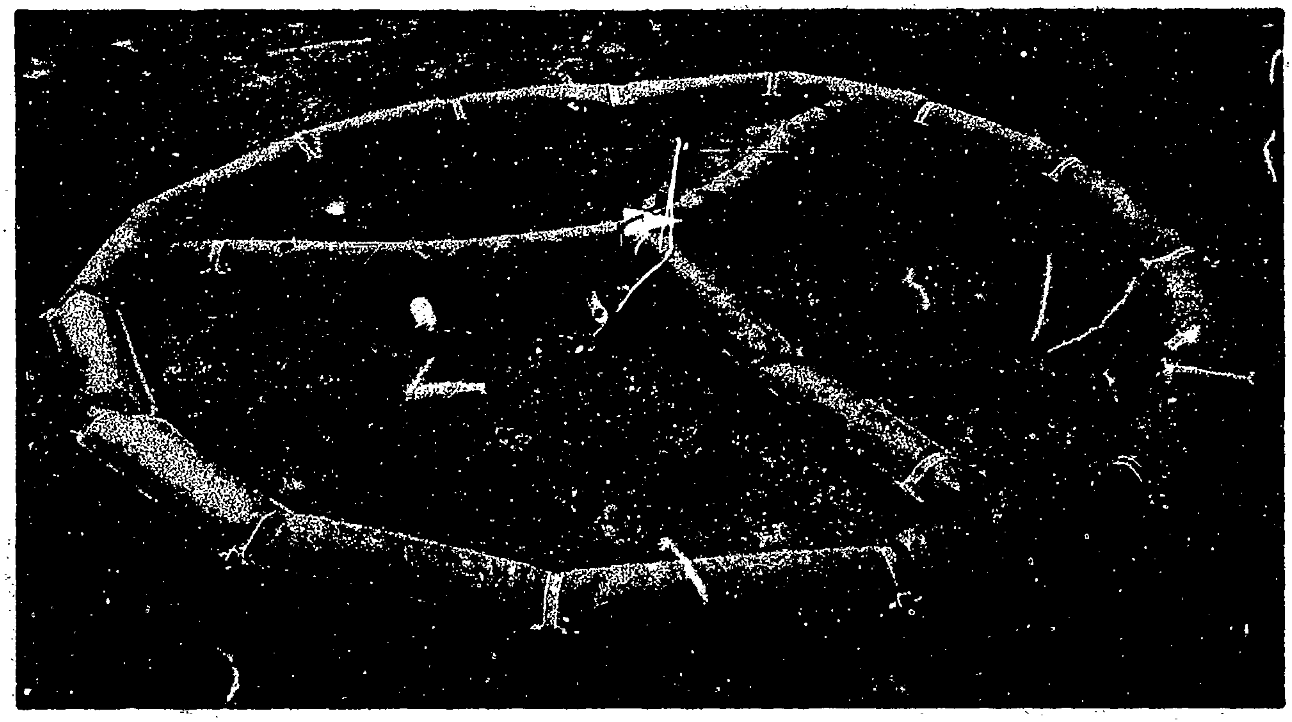


Figure 3. Deflated array structure in the form of a spider.

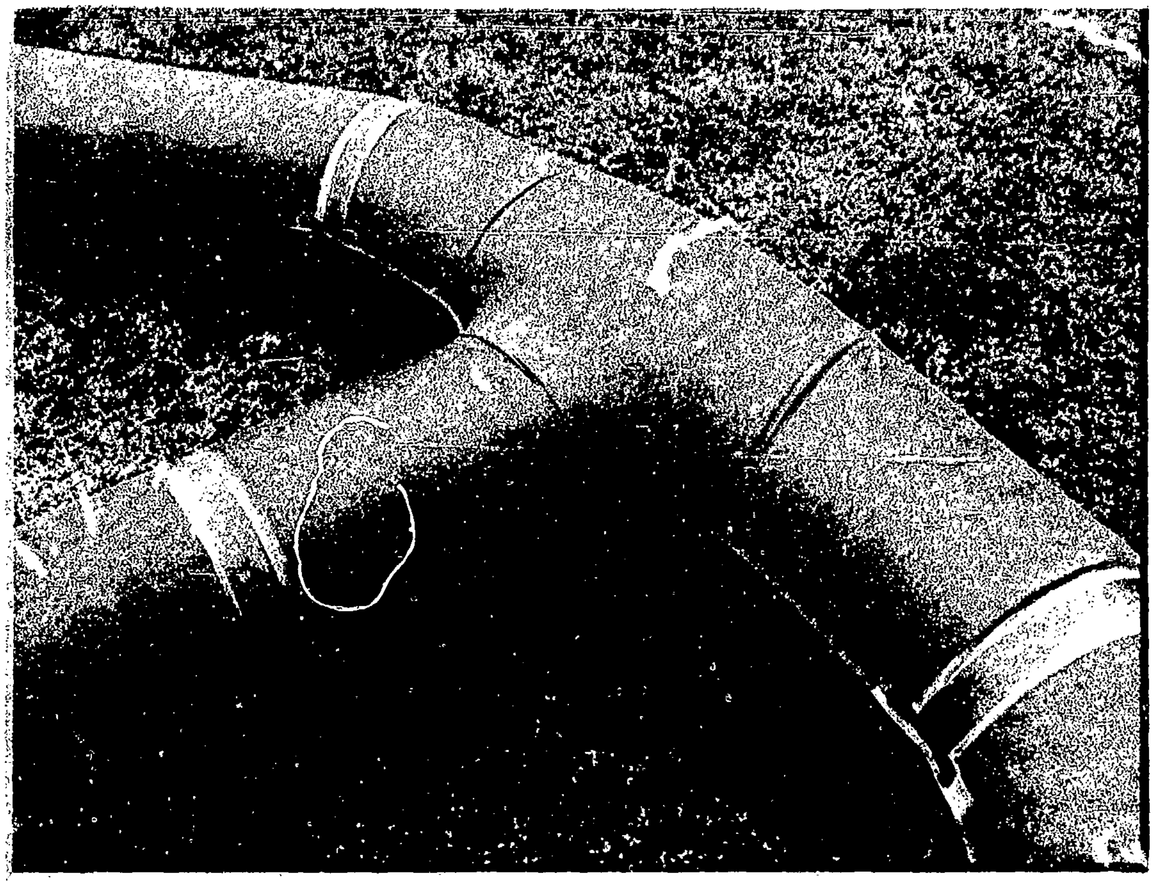


Figure 4. Structural detail of an inflated array structure.

installation of sensor arrays.

Another approach is feasible, however, that requires a minimum of diver man-hours and in some cases only one ship. This unique approach to underwater array structure design utilizes water-inflated fabric tubes as structural members of the array. The inflation of the tubes is a foolproof process which can be handled from a distance, so there is little need for divers during the deployment or inflation of the array. Because the stiffness of the array does not depend upon the tautness of stretched cables, only one ship may be required during deployment of the array and setting of the anchors that hold it in place.

Since an inflated tubular structure derives its rigidity from its geometry, size of tubular members, construction material, and internal pressure, all of these parameters need to be investigated so that the performance of existing inflatable arrays can be understood and used as the basis for future designs.

Figure 5. Assembling the inflatable array structure.

Figure 6. Structure for internal pressure proof testing.

During the past year, the study of inflatable arrays focused on the design, fabrication, and deployment of self-contained array structure assemblies that do not require the assistance of divers for their deployment. Three array structures in the shape of a spider, a triangle, and a torus served as test models. The tubular members of all the structures were 1 foot in diameter and each of the structures could fit inside a circle 20 feet in diameter.

The evaluation of these inflatable array structures was directed toward three distinctly different deployment conditions: inflation of the array when (1) suspended from a floating surface buoy, (2) resting on the bottom, and (3) suspended from a moored, subsurface buoy. Results of the tests indicate that the autonomous erection process of the inflatable array structures simplifies and significantly expedites the deployment of underwater array structures.

high speed towed sonar

The advent of high speed nuclear submarines has greatly reduced the effectiveness of conventional surface ships in antisubmarine warfare. The speed and stability required to combat nuclear submarines are to be found only in helicopters or in new, high performance surface craft such as the semisubmerged platform, surface effect ship, air cushion vehicle, and hydrofoil. Of these, only the helicopter and hydrofoil are operational. Studies conducted at NUC and the Naval Electronics Laboratory Center have shown that the hydrofoil can be developed as an effective antisubmarine weapon if it is equipped with a high speed sonar which will enable its crew to track enemy submarines at or near the hydrofoil's top speed.

For several years NUC has been engaged in developing a high speed towed sonar specifically designed for use with a hydrofoil but applicable to the semisubmerged platform and the surface effect ship as well. The initial effort culminated in the development of a winch, low-drag towline, and controlled towed body (figure 1).

During the past year the basic hardware has been developed into a test bed high speed sonar which can be towed from a helicopter or a hydrofoil. It was necessary to adapt the system for use with a helicopter because no hydrofoil was available for testing.

The major modification to the original equipment was the

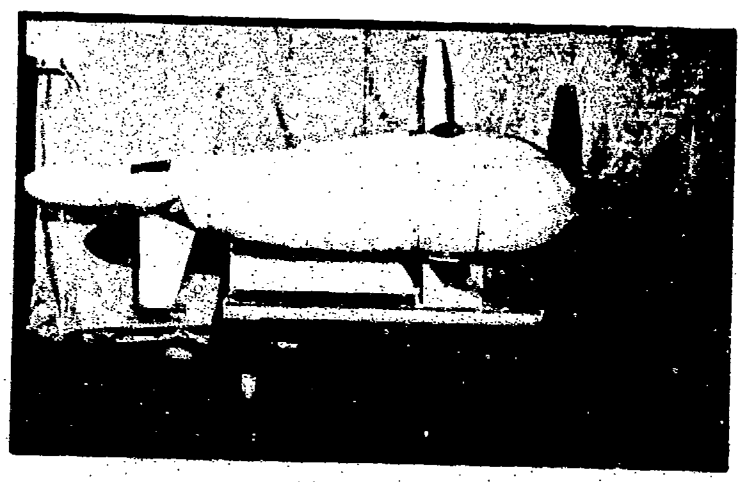


Figure 1. The towed body in its original configuration.

Figure 2. The towed body with MK-48 torpedo sonar installed.

F·jure 3. The command module.

installation of a MK-48 torpedo sonar. Torpedo sonar technology, in this respect, was utilized to minimize the development work necessary to attain high speed sonar operation. The towed body proved to be directionally unstable with the blunt-nosed torpedo sonar installed, and a box tail assembly was added to correct the instability (figure 2). One-quarter dynamically scaled models were used in the design and testing of the tail assembly. Additional modifications included the design and construction of a command module (figure 3) packaged for quick installation or removal aboard a helicopter, and alteration of the cable hook-up to permit towing of the controlled body of a helicopter. The command module enables the operator to control the tow angle and the body roll angle to provide the stability necessary for high speed towing maneuverability (figure 4). Control signals and power are transmitted to the towed body through one of two coaxial cables housed in the towline. The second cable feeds back to the operator sonar and body data including speed, depth, attitude, and control positions.

Now in the development stage at the Applied Research Laboratory at Penn State is a wide-angle search sonar transducer which can be adapted to the present system. With the incorporation of this transducer and associated electronics, this system will represent a prototype high speed towed sonar with which the hydrofoil's potential as an antisubmarine weapon can be demonstrated in fleet operations.

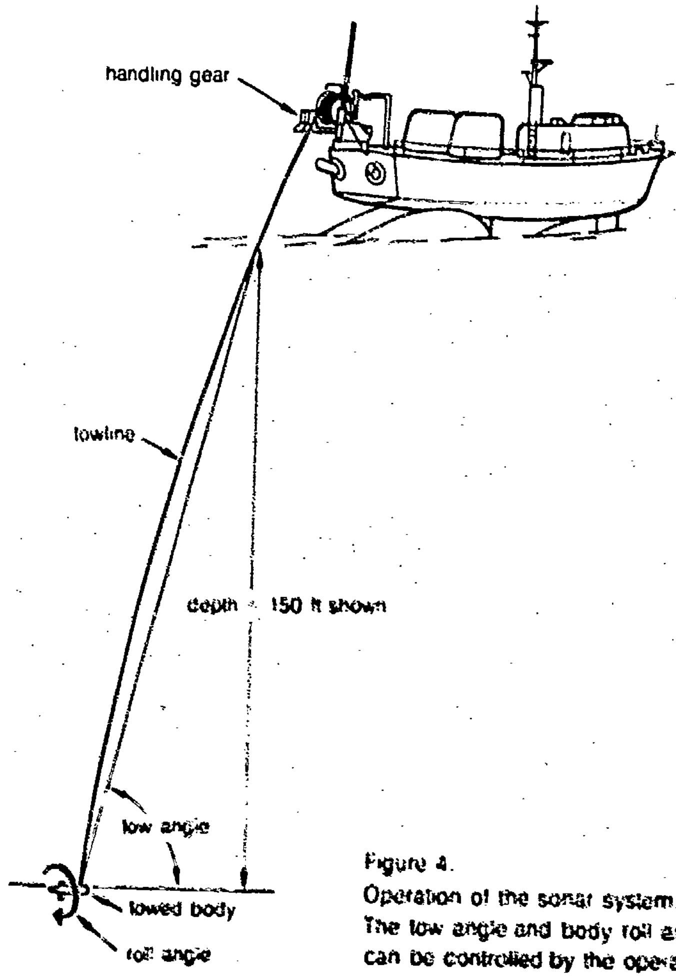


Figure 4.
Operation of the sonar system.
The tow angle and body roll angle can be controlled by the operator.

glass and ceramic viewports for underwater optical systems

Underwater vision is required for all systems engaged in ocean engineering or oceanographic exploration beneath the sea. For manned systems, large viewports are the most economical and reliable means of providing crew members with panoramic vision. Such viewports have been designed at NUC and both design and fabrication capability exists for spherical acrylic plastic windows with diameters up to 78 inches and thicknesses up to 6 inches. The large deflection experienced by acrylic plastic viewports under hydrostatic loading is not considered particularly objectionable to human observers because the eye adapts to the slight changes in optical images transmitted by the deforming window and extreme optical accuracy is not needed for general undersea observation.

Quite a different case presents itself for viewports that also serve as optical elements of an underwater television or camera system. In such a case the deformations of a typical plastic viewport become unacceptable, particularly under hydrostatic loading, as they significantly impair the quality of the optical image transmitted and make it unsuitable for photogrammetric work. The large deflections of the viewport can be eliminated, however, by substituting for the transparent plastic an inorganic material such as glass or ceramic which has a higher modulus of elasticity. Furthermore, by making the glass or ceramic viewports thinner than the plastic ones, substantial savings can be achieved in the weight of the subassembly.

During the past year work was completed on a glass or ceramic window-flange assembly offering panoramic vision at operational pressures up to 20,000 pounds per square inch. Research underway for approximately two years was concluded by successful testing of 18 assemblies to pressures exceeding those found at abyssal depths in the ocean (figure 1). Each assembly forms a self-sufficient structural element independent of the pressure hull on which it is to be mounted, so it can be adapted without change to many potential undersea applications.

Notable design features include the use of transparent ceramic or chemically surface compressed glass in a spherical shell configuration, flat bearing surfaces at the interface of the shell and the flange, and a bearing gasket of fiber-reinforced epoxy between the shell and flange.

Transparent glass ceramic and chemically surface compressed glass offer superior resistance to the tensile and flexural stress often encountered in spherical shell windows at the interface of the shell and the flange. The spherical shell configuration distributes the compressive stresses in the window without major concentrations and provides a less distorted and larger field of view than is provided by flat disc or conical frustum windows. A 150-degree sector is used because it provides almost the same field of view as a complete hemisphere while retaining the advantages associated with the fabrication and mounting of smaller spherical sectors. Additionally, the 150-degree sector is subject to smaller shear and tensile stresses at the interface of the shell and the flange than is a hemisphere.

The flat bearing surfaces of the shell and the flange are adequate for the stresses encountered but are less expensive than toroidal or spherical surfaces. They also make mass-produced windows and flanges readily interchangable in the field.

The fiber-reinforced epoxy gasket provides sufficient compliance for cushioning the point contacts resulting from an imperfect match between the shell and the flange while offering adequate strength to withstand the axial bearing stress of 80,000 pounds per square inch predicted for some locations on the interface of the shell and the flange.

Data from the hydrostatic tests support the following conclusions:

1. The 150-degree spherical window-flange assembly utilizing chemically surface compressed glass or transparent ceramic has a proven fatigue life of at least 300 cycles with 8-hour operation at a hydrostatic pressure of 20,000 pounds per square inch.

2. Epoxy PRD-49 cloth or neoprene-impregnated nylon cloth Fairprene 5722A are acceptable bearing gaskets for the window-

Figure 1. Fabrication and testing of [illegible] window-flange assembly.
(a) The outer and inner radii of the spherical shell are ground to within 0.010 inch of specifications and the included angle of the bearing surfaces is brought to within 1 minute of 150 degrees.
(b) Prior to testing each viewport is disassembled and each component carefully checked for compliance to specifications.
(c) For hydrostatic testing five viewport assemblies are mounted on thick steel bulkheads and placed in a jig that keeps them separated within the pressure vessel.
(d) An assembled NUC window-flange assembly is shown prior to installation in an unmanned undersea vehicle.

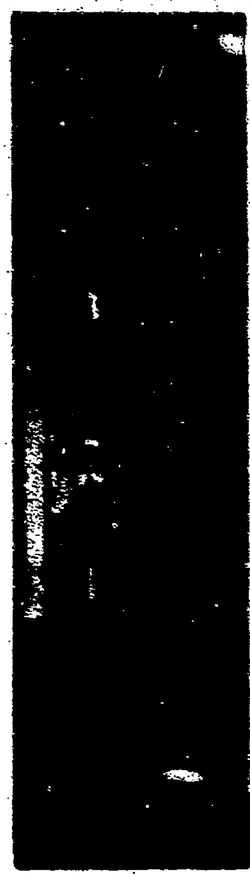
b

a

flange assembly providing that the hydrostatic pressure does not exceed 20,000 pounds per square inch. The cycle fatigue life of epoxy PRD-49 gaskets appears to be of an order of magnitude higher than that of Fairprene 5722A at a hydrostatic loading of 20,000 pounds per square inch.

3. Chemically surface compressed gas is significantly superior in structural applications to annealed glass and transparent glass ceramic CERVIT C-101 when the structure is subjected to tensile stresses but poses no significant advantages when the structure is subjected only to compressive stresses.

4. Transparent glass ceramic CERVIT C-101 is moderately superior in structural applications to annealed glass regardless of whether the structure is subjected to tensile or compressive stresses.



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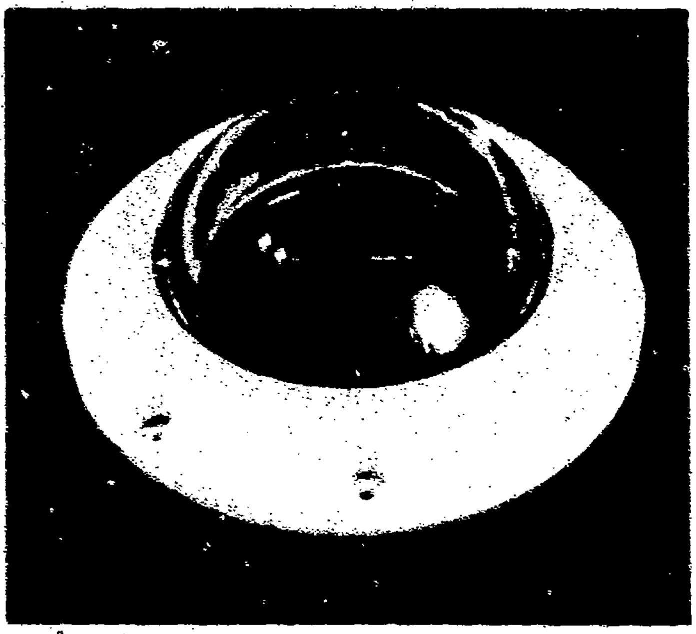


d

ultrasonic imaging using a surface wave delay line

The absorption and scattering of light by sea water severely limit the ability of divers and operators of undersea vehicles to visualize their surroundings. Useful optical ranges are limited to about 100 feet in relatively clear water. In conditions of considerable turbidity, the effective range can be reduced to near zero. The possibility of forming visible images by processing ultrasonic radiation scattered by objects in the water has been recognized for some time. During the past year an effort has been underway to develop an ultrasonic imaging device capable of providing real-time, high-resolution images at very short ranges to permit the use of manipulators and other tools in turbid water. The initial phase of the project was conducted at Stanford University with technical guidance and funding provided by NUC.

A schematic diagram of the experimental imaging device is shown in figure 1. Its operation can be described in several steps: (1) Ultrasonic waves scattered by objects in the field impinge on the array of piezoelectric transducers and generate electrical signals at the frequency of the waves, typically about 3 MHz. (2) A higher frequency (50 MHz) surface wave is launched down the delay line. This is a physical wave like a wave on the surface of the ocean. Taps on the line generate electrical signals as the surface wave passes. (3) The nonlinear, forward-biased diode located at each tap mixes the ultrasonic wave and surface wave signals. Outputs are generated in the diode chain at the sum and difference frequencies (47 and 53 MHz). These signals, which can be separated from the carrier frequency by bandpass filtering, contain the information on the acoustic wave field.

This information is extracted by applying a linear frequency sweep or chirp signal to the surface wave line. The surface wave generated by this signal activates all the taps

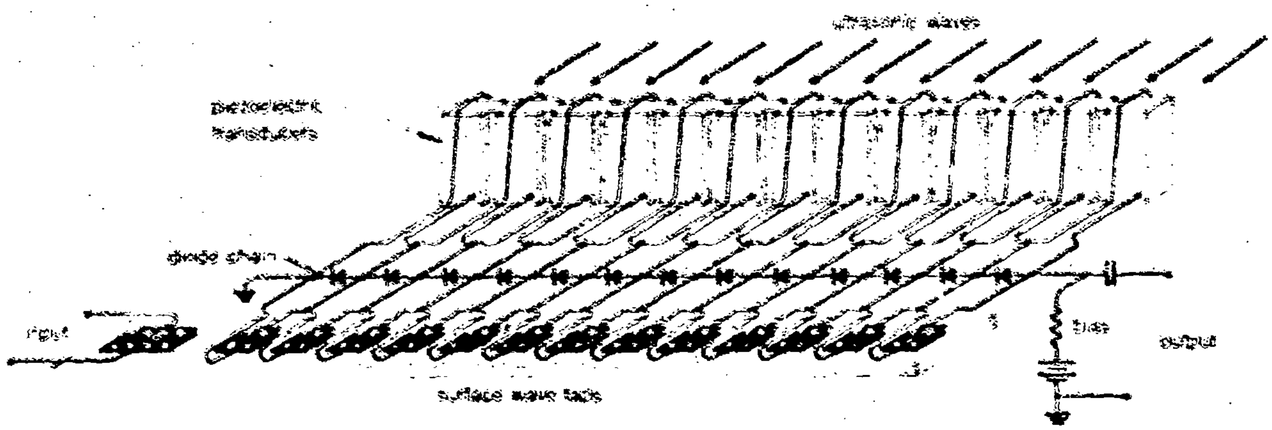


Figure 1 Schematic of the ultrasonic imaging device

along the delay line simultaneously so that the output of the diode chain is a summation of the signals produced by all the piezoelectric transducers. Phase shifts characteristic of a spherical wave are compensated for by phase shifts in the surface wave delay line. When the chirp signal is applied, the array is effectively focused at a point of finite range. As the chirp passes through the delay line, the focus point scans across the field of view. The range of focus is determined by how rapidly the frequency of the chirp is varied. This approach offers the possibility of electronically variable, focused imaging at very close range.

The concept has been experimentally verified for a one-dimensional array. Figure 2 shows a photograph of the ultrasonic image of the head of a small crescent wrench. Horizontal resolution was achieved by electronic scanning of a one-dimensional array consisting of 30 elements, while vertical resolution was achieved by mechanical scanning.

Plans for future work on the ultrasonic imaging system call for increased effort by both NUC and Stanford. The work at NUC will center on implementation of an improved version of the present one-dimensional array. This device will be suitable for experimentation at an acoustic test facility such as TRANSDEC. Some form of cylindrical lens or reflector system may be used to provide an interim two-dimensional imaging capability.

The program at Stanford will concentrate on advancing the technology of electronic imaging. Improved mixers using field effect transistors instead of diodes will be investigated for the one-dimensional array. In addition, a novel method of implementing two-dimensional imaging will be studied. If this method is developed successfully, an NXN array could be scanned using only two surface wave delay lines.

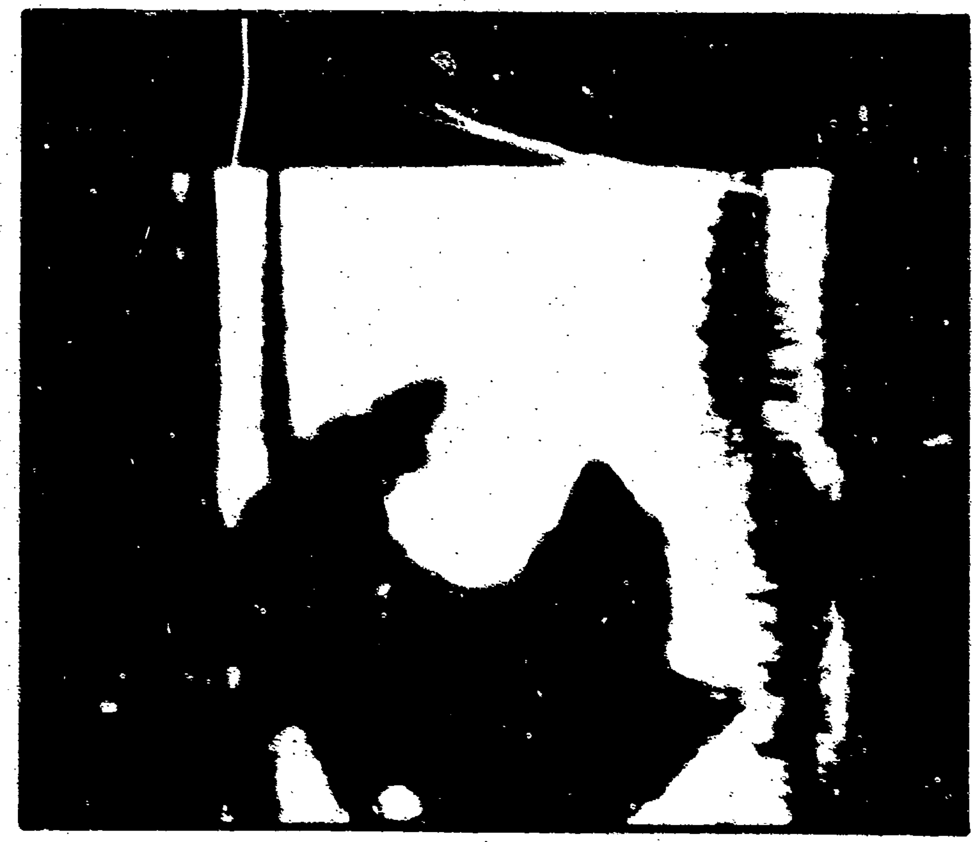


Figure 2 Ultrasonic image of the head of a small crescent wrench

fiber optic cables

Coaxial cables are widely used to transmit data over long distances underwater. However, data rates and transmission distances achievable using coaxial cables are limited by cable size and by the solid dielectric construction required to resist hydrostatic pressure. Optic fibers offer high data rates and transmission distances independent of the size of the fiber bundle. If optic fibers can be successfully incorporated into cables, they will provide small, lightweight transmission lines capable of conducting large volumes of data.

An effort has been underway for several years at NUC and at the Naval Electronics Laboratory Center to develop fiber optic cables which can be produced in useful lengths at reasonable cost. The general experimental approach has been to work with a small family of cables offering a variety of designs from which a broad base of data could be extracted.

Four experimental fiber optic cables fabricated during this work are shown in figure 1. On the right is a fiber optic bundle consisting of loosely held glass fibers jacketed with polyvinylchloride (PVC). The primary goal in the design of each was to protect the glass from compression or tension during manufacture and use of the cable. Each design was evaluated in terms of the percentage of the optic fibers broken during the manufacture of a given length of cable. This criterion was selected because any optic fiber broken is completely subtracted from the light path, unlike a broken strand in a coaxial cable, which continues to play a reduced role in conduction. For optic bundles containing less than 100 fibers, breakage is critical; cables several kilometers long are feasible only if breakage can be reduced to a very low level.

Since traditional cable making methods exert very great forces on the cable during its manufacture and the glass optic fibers are more fragile than copper wire, an alternative, experimental technique was used in the fabrication of the first of the four cables. Glass strands were molded in an epoxy matrix surrounding the central signal core. Two copper wires were included to conduct electricity. The resulting cable proved to be torque-balanced and possessed high strength-to-weight properties. However, some 50 percent of the optic fibers were broken in the manufacture of only 3 feet of cable. Heat applied during molding apparently hardened the PVC jacket surrounding the optic fibers and produced a rough internal surface.

The second cable was fabricated by more traditional methods and was armored with a double lay of steel wires wrapped in opposite directions about the central core to provide torque balance. In this and the following two cables, the glass bundle was twisted with two conventional copper wires at the

Figure 1. Experimental fiber optic cables with fiber optic bundle. The fiber optic bundle is on the right. The cables, from left to right, are of molded glass, knitted steel, PRD-49, and wrapped steel. Note that the cables are not shown in the order in which they were developed.

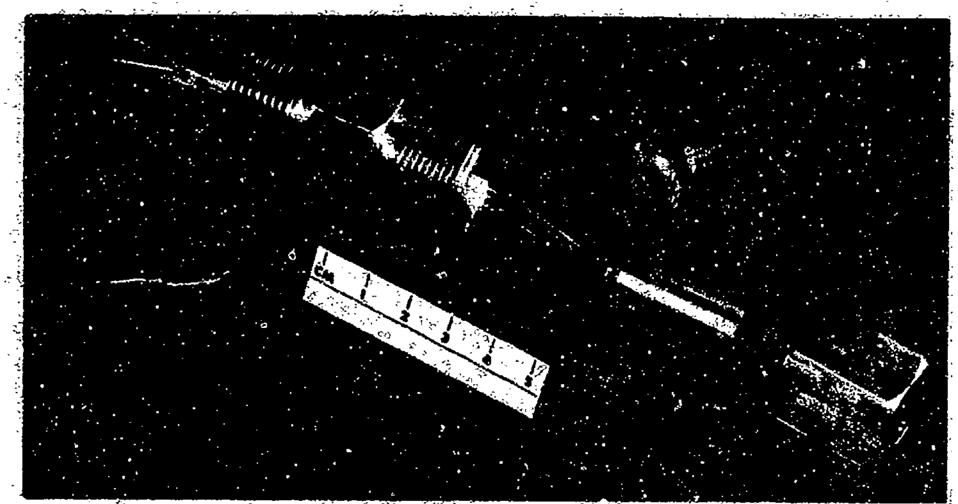


Figure 2. Pressure barrier penetrators.
(a) Penetrator using several strands of CROFON.

rate of one twist per inch of cable in an attempt to introduce slack and provide some tolerance for longitudinal stress. Nevertheless, breakage amounted to approximately 50 percent of the fibers in 3 feet of cable. This was attributed to the high compressive forces exerted during armoring.

The next cable employed steel wires knitted about the central core. Since compressive forces exerted on the wires during knitting are lower than those exerted in wrapping the wires about the central core, this design was expected to offer a lower rate of breakage. This was observed; 50 percent of the glass fibers were broken in manufacturing 60 feet of cable. This rate of breakage was considered to be still too high and was thought to be caused by the central core being too tightly twisted.

The final design used a knitted cover made of PRD-49, a limber, lightweight plastic offering high strength. Breakage was similar to that observed for the knitted steel cable.

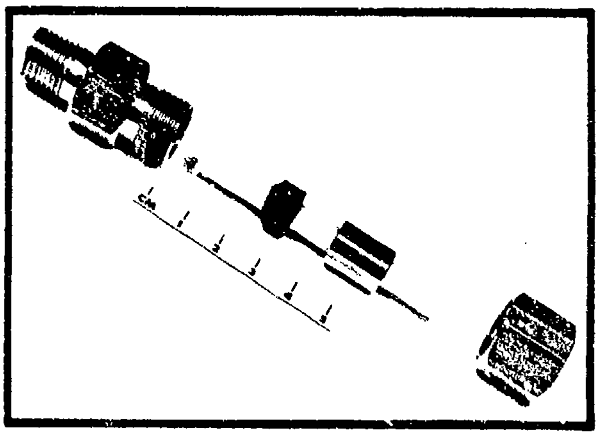
Two cables presently under construction will use new low-loss optic fibers in the central core. Each will be covered by a double lay of PRD-49 strands wrapped in opposite directions. The optic fiber bundle will be less tightly twisted in an effort to reduce breakage. Since PRD-49 has not been used in this configuration, these cables will contribute to a growing body of data on fiber optic cable design.

Still lacking is design data relative to long-term behavior of optic fibers under repeated bending and twisting. Cable life predictions cannot be made until these numbers have been accumulated.

As an adjunct to fiber optic cables, penetrators are required to pass optical signals through pressure barriers. During the past year, two types of penetrators were designed, fabricated, and tested. The first type, shown in figure 2, uses several strands of a light-conducting plastic (CROFON) for the light conduit. This material attenuates light too severely to transmit optic signals over long distances, but it is physically durable and suitable for a short plug. The fibers are retained in a standard compression fitting (Conax). Pressure tests to 10,000 pounds per square inch revealed no leaks.

The second penetrator, shown in figure 3, uses a solid rod of fused fiber optic bundles ¼ inch in diameter and 3½ inches long. The cylindrical rod, like the loose fibers, is retained in a compression fitting. An optical image formed on one end of the rod appears slightly attenuated at the other. These rods can be made in various shapes such as cones and can even be bent during manufacture without damage.

Several advantages rest with the optical connector as compared with the electrical. There is no strict requirement for electrical insulation. In fact, one pressure test conducted with water leaking across the boundary produced no noticeable degradation in performance. Also, high- and low-level signal forms can share one connector, since optical cross talk is not a problem. Even electrical power lines can pass through a common plug.



(b) Penetrator using solid rod of fused optic fibers.

small, unmanned, tethered submersibles

Small, unmanned, tethered submersibles offer advantages over diver systems or general-purpose submersibles for undersea inspection, surveillance, implantment, and recovery. They are safer, more easily transported, cost less to develop and operate, and provide unlimited endurance. Submersibles developed at NUC during the past two years range in size from CURV (for "cable-controlled underwater recovery vehicle"), designed to recover large objects such as torpedoes, to tiny SNOOPY, designed to implant or recover small objects weighing up to 4 pounds. Development of submersibles has continued during the past year with the upgrading of the SCAT test vehicle (for "submersible cable-actuated teleoperator"), successful testing of a new tracking system designed for use with small unmanned submersibles, and design and fabrication of an entirely new submersible, ELECTRIC SNOOPY.

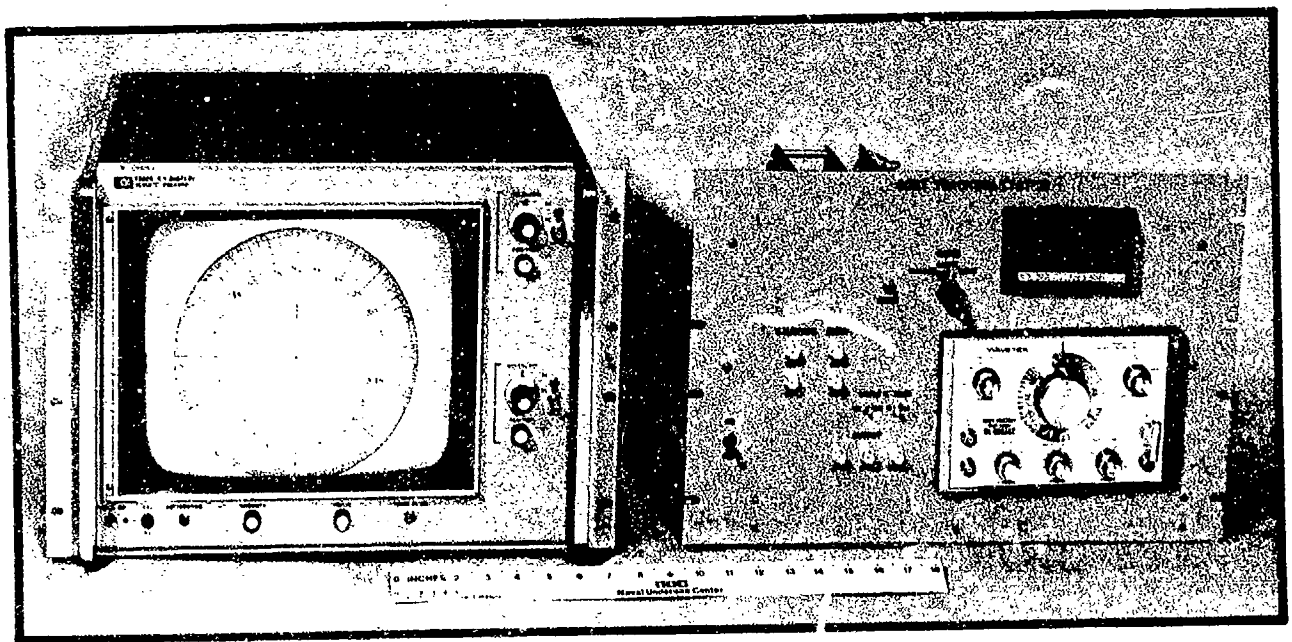


Figure 1. SCAT tracking system.

SCAT, one of the most versatile submersibles developed at NUC, was designed to develop, demonstrate, and evaluate advanced teleoperator concepts such as head-coupled stereoscopic television, and to provide a mobile undersea test bed for evaluation of future equipment, instrumentation, or vehicle control concepts. During the past year, SCAT's original 500-foot tether was replaced with a 2000-foot tether to permit deeper operations. The longer cable, like the original, is a multiconductor which passes three-phase 60-Hz electrical power, television, sonar, and a limited number of control and sensor signals. A new, multiplexed tether combining power, control, and sensor signals on a triaxial cable was demonstrated in the laboratory and will significantly improve SCAT's capability when it is added to the test vehicle. The new cable is of smaller diameter and is more flexible than the cable currently in use. It is expected to reduce underwater cable drag by a factor of 2.5, greatly facilitate cable handling, and largely increase the volume of information exchanged between SCAT and its surface support ship.

Also demonstrated was a prototype multiplexed communication system compatible with the new cable.

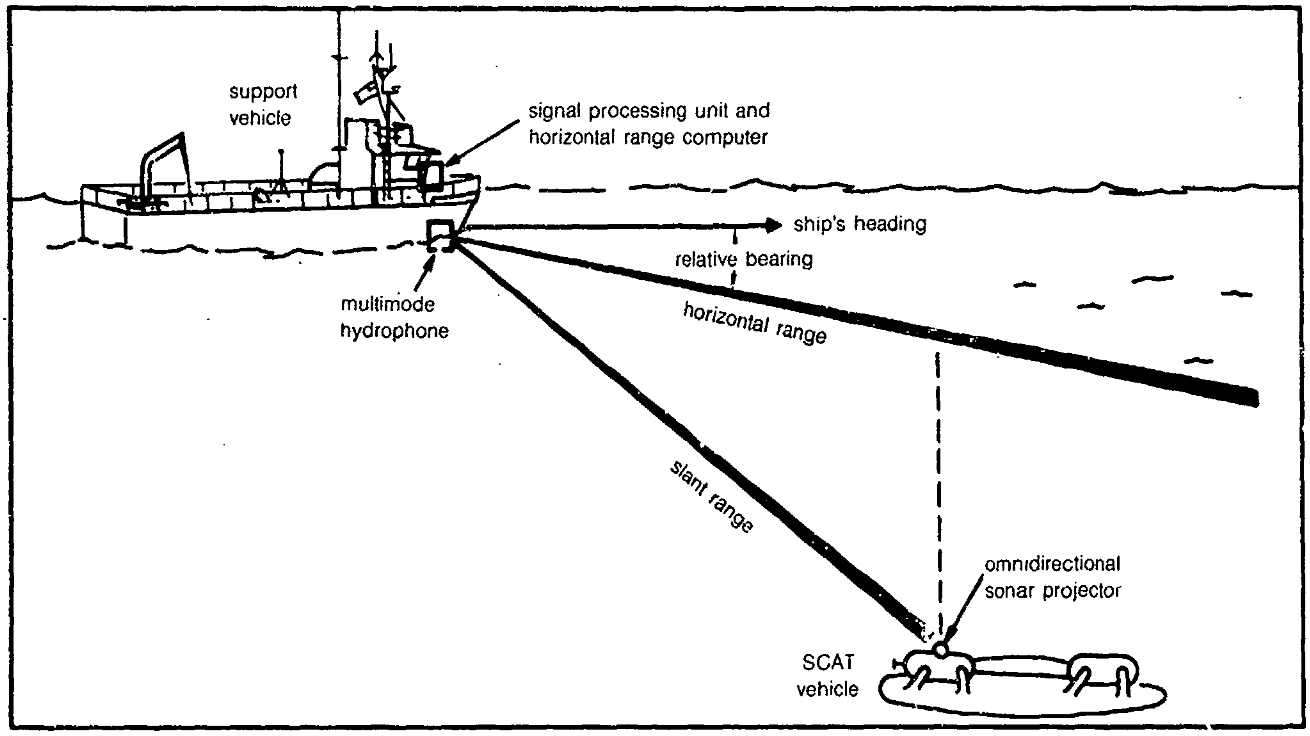


Figure 2. Operation of SCAT tracking system.

Using the latest amplitude-modulated solid-state circuitry, the system permits simultaneous transmission of two real-time black-and-white television signals, real-time sonar signal, and 55 sensor signals (36 independent on-off discrete signals and 19 independent analog signals) from SCAT to the surface ship along the triaxial cable. For control, another set of 36 independent on-off discrete signals and 19 analog signals may be simultaneously transmitted down to SCAT along with three-phase electrical power.

Because the volume of control and sensor signal channels exceeds that required for operation of SCAT itself, the extra discrete and analog channels are available for use in the operation and monitoring of experimental systems.

The SCAT Tracking System (figure 1) was developed to provide a simple system requiring little set-up preparation. Its primary component is a multimode hydrophone aboard the surface support ship which receives acoustic signals from an omnidirectional sonar projector attached to the submersible. The signals received are processed to determine the horizontal range of the sumbersible and its bearing relative to the support ship. Horizontal range and relative bearing are displayed on a cathode-ray tube; horizontal range is also displayed digitally (figure 2).

A new submersible designed at NUC during the past year is ELECTRIC SNOOPY. This vehicle combines the advantages of small size and light weight with the capability to perform useful work at continental shelf depths (to 1500 feet). The preliminary design of ELECTRIC SNOOPY is illustrated in figure 3. Three oil-filled electric motors propel the vehicle. A streamlined fiberglass hull protects the electronics pressure housing and interconnecting cables and improves the vehicle's drag characteristics, making it less susceptible to fouling in seaweed. The cutaway portion of figure 3 shows the fiberglass balls used for flotation and the lead ballast located low in the vehicle. The resultant separation of the center of buoyancy and the center of gravity

provides the vehicle with inherent pitch and roll stability. Kort nozzles on the horizontal thrusters further reduce chances of vehicle entanglement and provide a considerable improvement in thrust efficiency. Vehicle power, control signals, and television signals are multiplexed onto a single, small diameter coaxial tether to improve vehicle response by reducing cable drag and to facilitate cable storage and handling.

Horizontal excursions of ELECTRIC SNOOPY are controlled with a single proportional joystick. Vertical excursions are controlled using a lever on the console which adjusts the speed and direction of the vertical thruster. When this control lever is returned to its central position, sample-and-hold circuitry on the vehicle automatically maintains existing vehicle depth.

To reduce signal multiplexing complexity, a specially designed heading and depth readout at the vehicle is relayed to the control console through the television system.

A remotely operated Kodak Low Light Super 8 camera is used for still photographs and motion picture documentation. This camera offers the capability of obtaining photographic documentation at illumination levels typically found in shallow water. When required for deeper or night operations, the television light or small auxiliary light will provide adequate illumination.

It is anticipated that small size and weight, ease of operation, and minimal support requirements will make this vehicle and others of its type useful and effective for a variety of undersea tasks.

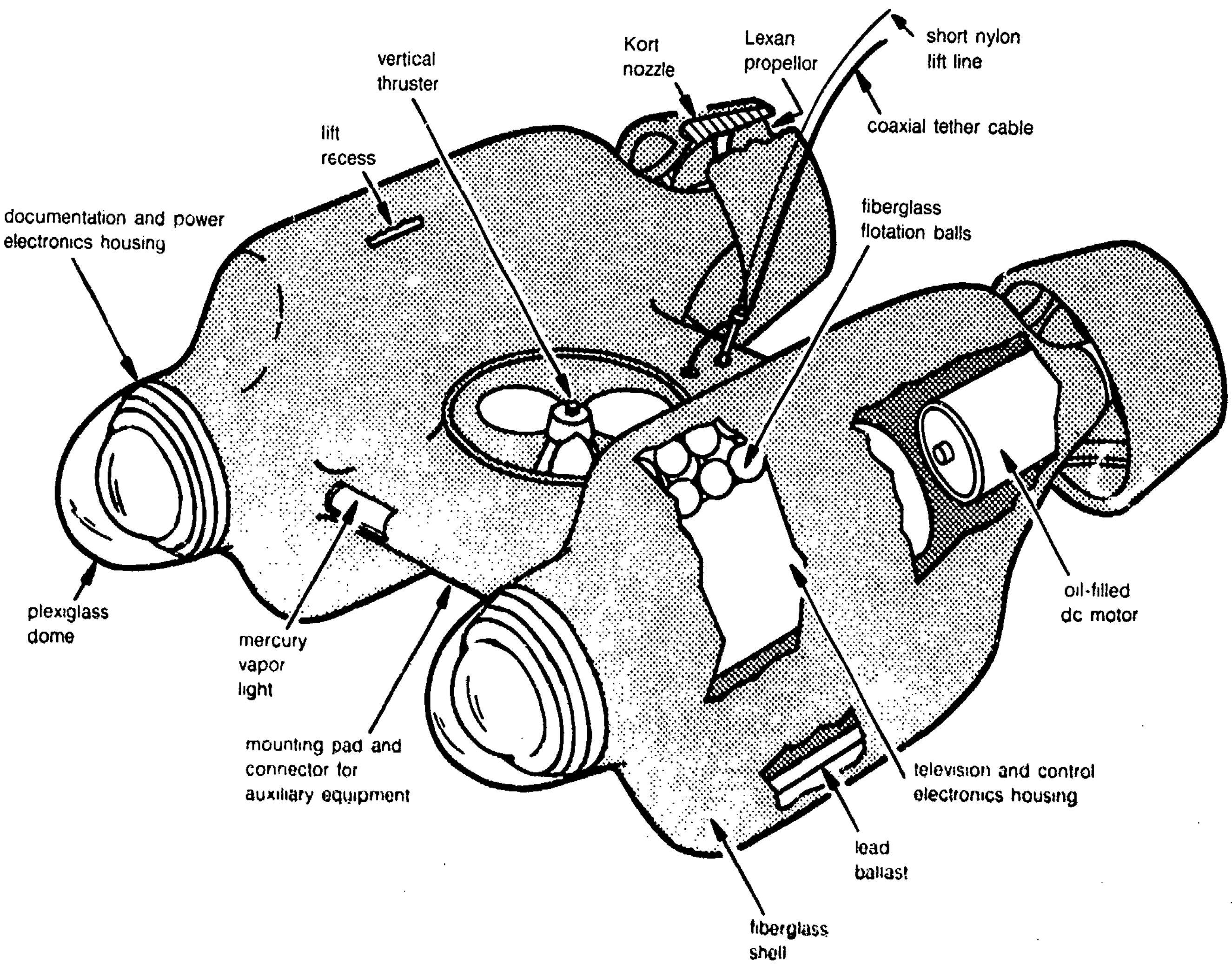


Figure 3. ELECTRIC SNOOPY.

projects active or terminated since last annual report

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INDEPENDENT RESEARCH PROJECTS

ACTIVE PROJECTS

Project Title and Principal Investigator	Task Area	Fiscal Year 1973 Funding	Fiscal 1974 Funding	Key to NARDIS Report
Determinants of Dolphin Motivation R. L. Pepper, Code 403 808-257-6121	ZR 000-01-01	$ 17,000	$ 24,000	Unavailable
Tensile Strength of Water and Polymer Solutions J. W. Hoyt, Code 2501 213-449-7471	ZR 000-01-01	5,000	2,200	Unavailable
Acoustic Research on Tuna/Porpoise Program J. Fish, Code 405 714-225-6463	ZR 011-08-01	0	11,000	Unavailable
Diving Characteristics of False Sonar Targets J. Fish, Code 405 714-225-6463	ZR 011-08-01	0	17,000	Unavailable
Flow Noise/Vibration Theory J. Hunt, Code 601 714-225-6301	ZR 011-08-01	0	5,000	Unavailable
Volume Reverberation: Quantitative Evaluation of Its Causes, Characteristics, and Variation W. A. Friedl, Code 503	ZR 011-08-01	0	102,500	Unavailable
Rate of Solubility of Hydrogen Gas S. Yamamoto, Code 5045 714-225-7828	ZR 011-08-01	0	40,000	Unavailable
TENSOR Analysis of Sampled Data C. Johansen, Code 252 213-449-7440	ZR 014-02-01	0	20,000	Unavailable
Underwater Visibility Model A. Gordon, Code 6511 714-225-6686	ZR 014-08-01	15,000	2,000	DN 234 617
New Concepts Development H. J. Whitehouse, Code 6003 714-225-6315	ZR 021-02-01	115,000	75,000	DN 234 678

Project Title and Principal Investigator	Task Area	Fiscal Year 1973 Funding	Fiscal Year 1974 Funding	Key to NARDIS Report
Sonar Signal Processor Implementation Study — Digital Signal Processor Error Analysis L. P. Mulcahy, Code 603 714-225-7678	ZR 021-05-01	$ 22,000	$ 5,000	DN 234 809
Chemistry at the Sea-Sediment Interface S. Yamamoto, Code 5045 714-225-6340	ZR 031-02-01	70,000	25,000	DN 118 746
Effect of Benthic Marine Animals on Ordnance M. H. Salazar, Code 25406 213-449-7464	ZR 031-02-01	25,000	25,000	DN 949 319
Radiotelemetry of Clinical Data from Marine Mammals R. S. Seeley, Code 102 714-225-7839	ZR 031-02-01	40,000	30,000	DN 234 621
Sound Scattering and Trace Element Distribution in the Sea H. V. Weiss, Code 5045 714-225-6340	ZR 031-02-01	70,000	30,000	DN 118 747
Bioacoustic Capability of Marine Mammals, Code 403 808-254-4479	ZR 041-08-01	0	45,000	Unavailable
MINOX Program G. V. Pickwell, Code 5045 714-225-7829	ZR 041-08-01	0	30,000	DN 234 706
Evaluation of Bioassay Techniques M. H. Salazar, Code 2542 213-449-7464	ZR 041-09-01	0	23,000	Unavailable
Bioluminescence Due to Turbulence in Water J. W. Hoyt, Code 2501 213-449-747[illegible]	ZR 041-26-01	0	1,000	Unavailable

TERMINATED PROJECTS

Project Title and Principal Investigator	Task Area	Fiscal Year 1973 Funding	Key to NARDIS Report	Reason for Termination
Stochastic Model for Sonar Variability J. A. Neubert, Code 454 213-449-7564	ZR 000-01-01	$ 2,000	Unavailable	Completed
Advanced Noise Canceler R. H. Hearn, Code 252 213-449-7521	ZR 011-08-01	40,000	DN 334 606	Completed
Distributed Acoustic Sensors T. G. Horwath, Code 6001 714-225-6315	ZR 001-08-01	10,000	DN 234 607	Funds discontinued
General Purpose Linear Processor (GPLP) with Applications to Sonar J. M. Alsup, Code 6021 714-225-6607	ZR 011-08-01	27,000	DN 234 605	Funds discontinued
Stochastic E-L Approach to Wave Propagation J. A. Neubert, Code 4543 213-449-7567	ZR 011-08-01	10,000	DN 234 813	Completed
VLF Acoustic Analysis G. E. Martin, Code 601 714-225-6686	ZR 011-08-01	15,000	DN 334 605	Completed
Artificial Pinna (Outer Ear) for Application to Undersea Research and Exploration G. W. Byram, Code 6021 714-225-6607	ZR 011-09-01	10,000	DN 949 310	Completed
Structural Radiation Interaction Modeling of Simple Array of Sonar Transducers J. T. Hunt, Code 601 714-225-6301	ZR 011-10-01	40,000	DN 234 710	Completed
Solubility of Hydrogen Gas in Seawater and Distilled Water S. Yamamoto, Code 5045	ZR 013-01-01	36,000	DN 234 710	Completed
A Stochastic Model for Acoustic Channels L. K. Arndt, Code 502 714-225-7620	ZR 014-05-01	12,000	DN 234 645	Manpower limitations

Project Title and Principal Investigator	Task Area	Fiscal Year 1973 Funding	Key to NARDIS Report	Reason for Termination
Analysis of a Triangular Element Cylinder as a Pressure-Resistant Structure R. H. Knapp, Code 6532 808-257-2161	ZR 104-20-01	$ 12,000	DN 234 810	Completed
Conversion of AN/SQQ-56A Bathythermograph for Sound Speed Measurements J. G. Colburn, Code 502 714-225-7620	ZR 021-03-01	15,000	DN 234 866	Funds discontinued
Pull-Down Retriever Unit E. R. Rosenberg, Code 6508 714-225-6862	ZR 023-03-01	1,500	DN 234 863	Funds discontinued
Structural Design of S' Semisubmerged Ships P. L. Warnshuis, Code 608 714-225-6497	ZR 023-03-01	90,000	DN 334 646	Completed
Hydrodynamic/Thermodynamic Theory for Predicting Highly Variable Oceanic Conditions Within Small Regions of the Ocean J. H. Brown, Code 90 714-225-6737	ZR 031-01-01	8,000	DN 234 686	Manpower limitations
Study of Marine Mammal Population to Assist Evaluation of Effect on ASW and Assessment of Study of Animals for Systems Concepts W. E. Evans, Code 402 714-225-7841	ZR 031-02-01	40,000	DN 848 445	Completed
Shark Countermeasures for Protection of Navy Swimmers C. S. Johnson, Code 4002 714-225-7839	ZR 031-02-01	15,000	DN 949 317	Completed
Marine Natural Resource Survey J. A. Beagles, Code 6543 714-225-7911	ZR 031-03-01	25,000	DN 334 636	Completed
Stick Sampler J. W. Hoyt, Code 2501 213-449-7471	ZR 031-03-01	15,000	DN 234 783	Completed

Project Title and Principal Investigator	Task Area	Fiscal Year 1973 Funding	Key to NARDIS Report	Reason for Termination
Solidification and Super-Cooling of Sea Water in Arctic Submarine Research C. Richardson, Code 90 714-225-6737	ZR 032-05-01	$ 54,000	DN 848 447	Funds discontinued
Detrimental Microbial Activities in Hyperbaric Facilities P. R. Kenis, Code 2542 213-449-7464	ZR 041-05-01	23,000	DN 134 618	Funds discontinued
Environmental Impact Study of SCI Sewage P. R. Kenis, Code 2542 213-449-7464	ZR 041-05-01	30,000	DN 134 617	Completed

INDEPENDENT EXPLORATORY DEVELOPMENT PROJECTS

ACTIVE PROJECTS

Project Title and Principal Investigator	Task Area	Fiscal Year 1973 Funding	Fiscal Year 1974 Funding	Key to NARDIS Report
Adaptive Line Enhancing R. Hearn, Code 252 213-449-7523	ZF 61-112-001	$ 0	$ 40,000	Unavailable
Automatic Detection of Communication Signals D. Gingas, Code 603 714-225-6249	ZF 61-112-001	0	38,000	Unavailable
Dual Lens Sonar P. Warnshuis, Code 6005 714-225-6498	ZF 61-112-001	0	30,000	Unavailable
Echo Elongation F. Marshall, Code 3525 213-449-7577	ZF 61-112-001	0	20,000	Unavailable
Evaluation of Target Classification Concept H. Volberg, Code 6531 808-254-4311	ZF 61-112-001	0	22,000	Unavailable
Improve CURV Detection Capability H. J. Whitehouse, Code 6003 714-225-6315	ZF 61-112-001	125,000	9,000	Unavailable
Induced Doppler Sonar T. Keil, Code 651 714-225-7629	ZF 61-112-001	0	20,000	Unavailable
ROMS Design Study P. Heckman, Code 6511 714-225-6686	ZF 61-112-001	0	2,000	Unavailable
Signal Processing Imager H. Whitehouse, Code 601 714-225-7650	ZF 61-112-001	0	50,000	Unavailable
Surface Effects Detection C. Ramstedt, Code 606 714-225-6498	ZF 61-112-001	0	48,000	Unavailable
Target Identification by Harmonic Frequency Detection J. Huang, Code 608 714-225-6872	ZF 61-112-001	0	30,000	Unavailable
VLF Broadband Flat Response Transducer F. R. Abbott, Code 601 714-225-7505	ZF 61-112-001	37,000	22,000	DN 334 626

Project Title and Principal Investigator	Task Area	Fiscal Year 1973 Funding	Fiscal year 1974 Funding	Key to NARDIS Report
Optical Data Multiplexing for Towed Arrays J. T. Redfern, Code 6021 714-225-6613	ZF 61-212-001	$ 88,400	$ 8,000	DN 118 800
Acrylic Pressure Hull Technology J. D. Stachiw, Code 6505 714-225-7811	ZF 61-412-001	25,000	30,000	DN 234 611
Closed Cycle Power Pod A. D. Rathsam, Code 608 714-225-6871	ZF 61-412-001	62,000	31,600	DN 234 830
Nonnuclear Submarine Tankers R. H. Bass, Code 608 714-225-6871	ZF 61-412-001	16,000	9,500	Unavailable
Radio-Controlled Sonar Vehicle J. Clifton, Code 608 714-225-6872	ZF 61-412-001	25,000	14,000	DN 234 829
Remotely Manned Vehicle Development R. Fugitt, Code 6512 714-225-7629	ZF 61-412-001	0	75,000	Unavailable
Superconducting Magnetometer W/NWC R. Means, Code 608 714-225-6872	ZF 61-412-001	0	40,000	Unavailable
Auto Manipulation Position System C. Morris, Code 6514 714-225-6871	ZF 61-512-001	0	10,000	Unavailable
Bragg Cell Construction B. A. Saltzer, Code 6513 714-225-6864	ZF 61-512-001	7,000	0	DN 234 796
Cooperative NUC/Norwegian Fishing Institute Study of Fish School Target Strength and Attenuation I. E. Davies, Code 503 714-225-7827	ZF 61-512-001	0	1,500	Unavailable

Project Title and Principal Investigator	Task Area	Fiscal Year 1973 Funding	Fiscal Year 1974 Funding	Key to NARDIS Report
Deep Ocean Dynamics P. Hansen, Code 504 714-225-6217	ZF 61-512-001	$ 0	$ 23,000	Unavailable
Deterministic Theoretical Investigation of Underwater Sound Propagation T. Barakos, Code 504 714-225-6404	ZF 61-512-001	0	27,000	Unavailable
Dual Hydro Winch S. Moran, Code 6513 714-225-6864	ZF 61-512-001	15,000	11,500	Unavailable
Electrophysiology of Dolphin Cortex S. H. Ridgway, Code 402 714-225-7838	ZF 61-512-001	30,000	30,000	DN 234 876
Helicopter Landing System W/NWC L. Gray, Code 655 714-225-7272	ZF 61-512-001	0	61,000	Unavailable
Light Valve Optical Processor J. Thorn, Code 6513 714-225-6864	ZF 61-512-001	0	25,000	Unavailable
Mission System Experiment M. M. Baldwin, Code 022 714-225-7957	ZF 61-512-001	0	50,000	Unavailable
Nonhuman Animal Guidance System R. R. Scule, Code 5055 808-254-4311	ZF 61-512-001	0	81,500	Unavailable
Pacific Pilot Whale: Evaluation of Its Effect on High Frequency Sonar and Its Feasibility as a Monitoring Platform W. E. Evans, Code 402 714-225-7839	ZF 61-512-001	30,500	7,500	DN 234 826
Postdetection Processing of Underwater Television Signals A. Gordon, Code 6511 714-225-6686	ZF 61-512-001	0	10,000	Unavailable

Project Title and Principal Investigator	Task Area	Fiscal Year 1973 Funding	Fiscal Year 1974 Funding	Key to NARDIS Report
Procedures for Evaluating Hardware and Tactics at Sea C. H. Sturtevant, Code 1401 714-225-7446	ZF 61-512-001	$ 500	$ 1,000	DN 234 673
Study of Target Classification Using Nonlinear Feature Selection Techniques J. A. Roese, Code 6032 714-225-7645	ZF 61-512-001	54,000	55,000	DN 234 807
Testing of 3000-Ton Semisubmerged Ship Model T. G. Lang, Code 608 714-225-6495	ZF 61-512-001	31,000	12,000	DN 334 645
Tools for Naval Inshore Warfare R. L. Seiple, Code 6530 808-257-2161	ZF 61-512-001	129,200	108,200	DN 118 727
Water Inflatable Arrays J. D. Stachiw, Code 6505 714-225-7811	ZF 61-512-001	32,000	50,000	DN 234 788
Video Storage and Retrieval B. Saltzer, Code 656 714-225-6864	ZF 61-512-001	0	13,000	Unavailable

TERMINATED PROJECTS

Project Title and Principal Investigator	Task Area	Fiscal Year 1973 Funding	Key to NARDIS Report	Reason for Termination
Low Cost Vehicle Support — LCVS A. J. Schlosser, Code 654 714-225-7147	ZF XX-412-001	$ 50,000	Unavailable	Completed
Acoustic Propagation — MATAI L. K. Duykers, Code 502 714-225-7646	ZF XX-512-001	0	Unavailable	Completed
Cluster Sand System Synthesis Analysis T. P. Norris, Code 0513 714-225-7112	ZF XX-512-001	0	Unavailable	Completed

Project Title and Principal Investigator	Task Area	Fiscal Year 1973 Funding	Key to NARDIS Report	Reason for Termination
Exploratory S^3 Semisubmerged Ship Structural Analysis T. G. Lang, Code 608 714-225-6495	ZF XX-512-001	$ 25,000	Unavailable	Completed
Preliminary Engineering — Sea Floor PUFFS K. E. Rogers, Code 501 714-225-7434	ZF XX-512-001	0	Unavailable	Funds discontinued
Acoustic Echo and Hull Vibration Analysis of Kamloops Data G. M. Coleman, Code 608 714-225-7505	ZF 61-112-001	30,000	DN 234 871	Completed
An Optical Signal Cross-Correlator for Active Sonar C. E. Persons, Code 6022 714-225-7669	ZF 61-112-001	47,000	DN 234 693	Completed
Color Sonar Displays H. W. Volberg, Code 6531 808-257-2161	ZF 61-112-001	60,000	DN 234 869	Completed
Development of VLF Acoustic Source F. M. Valenzuela, Code 356 714-225-7649	ZF 61-112-001	0	DN 234 637	Funds discontinued
Noise Field and Array Performance Comparison for the AN/BQR-7 on SSBN 619 and SSN 637 W. H. Marsh, Code 606 714-225-7131	ZF 61-112-001	0	DN 234 685	Completed
Spar Buoy Helicopter C. R. Nisewanger, Code 608 714-225-6497	ZF 61-112-001	0	DN 118 821	Funds discontinued
Submarine Hull Target Strength Reduction Analysis J. C. Huang, Code 603 714-225-7840	ZF 61-112-001	57,000	DN 234 636	Completed
Undersea Systems Countermeasure C. F. Ramstedt, Code 608 714-225-6498	ZF 61-112-001	5,000	DN 234 677	Completed

Project Title and Principal Investigator	Task Area	Fiscal Year 1973 Funding	Key to NARDIS Report	Reason for Termination
Underwater Signals G. W. Byram, Code 608 714-225-6498	ZF 61-112-001	$ 35,000	DN 234 778	Outside funding source
Glass-Ceramic Windows and Hulls for Submersibles J. D. Stachiw, Code 6505 714-225-7811	ZF 61-412-001	50,000	DN 234 667	Completed
Helo-Launch and Recovery Submersibles W. F. Mazzone, Code 6505 714-225-7812	ZF 61-412-001	0	DN 234 701	Completed
Marine Corps Applications for S^3 Semisubmerged Ships P. L. Warnshuis, Code 608 714-225-6497	ZF 61-412-001	50,000	DN 234 870	Completed
New Vehicle and Sonar Concept Studies T. G. Lang, Code 608 714-225-6495	ZF 61-412-001	25,000	DN 118 762	Completed
Small, Unmanned Vehicles J. L. Held, Code 6512 714-225-7629	ZF 61-412-001	169,000	DN 234 795	Completed
Submersible Glass Research W. R. Foreman, Code 6515 714-225-6630	ZF 61-412-001	0	DN 848 436	Completed
Acoustic Emission for Detection and Analysis of Failures in Glass P. J. Fetta, Code 4522 213-449-7318	ZF 61-512-001	0	DN 234 619	Funds discontinued
Acoustic Ray Theory and Target Localization E. R. Floyd, Code 503 714-225-6306	ZF 61-512-001	18,000	DN 234 827	Completed
Acoustic Scattering Models O. D. Grace, Code 603 714-225-7678	ZF 61-512-001	20,000	DN 234 808	Completed
Adaptive Analysis Separated Sensors M. S. Ball, Code 252 213-449-7420	ZF 61-512-001	4,000	Unavailable	Completed

Project Title and Principal Investigator	Task Area	Fiscal Year 1973 Funding	Key to NARDIS Report	Reason for Termination
Analytical Gain in Nonuniform Noise J. C. Reeves, Code 4543 213-449-7564	ZF 61-512-001	$ 5,000	Unavailable	Completed
Automation — Clinical Laboratory Information R. H. Riffenburgh, Code 504 714-225-7628	ZF 61-512-001	9,000	DN 234 827	Funds discontinued
Buoyancy Actuated Launch and Retrieval Elevator Support System (BALARE) J. B. Berkly, Code 6543 714-225-6292	ZF 61-512-001	0	Unavailable	Completed
Coaxial Piezoelectric Cable for Towed Arrays R. R. Smith, Code 601 714-225-6301	ZF 61-512-001	16,000	DN 234 794	Completed
Concrete Capabilities E. Johnson, Code 6512 714-225-7629	ZF 61-512-001	0	DN 234 622	Completed
Cryogenic Propellants and Exhaust Disposal for Undersea Power Systems H. E. Karig, Code 608 714-225-6495	ZF 61-512-001	0	DN 234 608	Completed
Development of Submersible Handling Equipment (Air Bearing, Launch Platforms) J. B. Berkley, Code 6543 714-225-7911	ZF 61-512-001	50,000	DN 234 820	Funds discontinued
Diver's Navigation System R. S. Acks, Code 6511 714-225-6686	ZF 61-512-001	15,000	DN 234 615	Funds discontinued
Glass Elevator — Direct Observation of Acoustic Scatterers M. W. Cooke, Code 6511 714-225-6686	ZF 61-512-001	0	DN 018 729	Completed
HASP Type Analysis B. L. Towle, Code 1511 714-225-6377	ZF 61-512-001	5,000	Unavailable	Completed

Project Title and Principal Investigator	Task Area	Fiscal Year 1973 Funding	Key to NARDIS Report	Reason for Termination
High Speed Towed Sonar Investigation R. J. Poynter, Code 356 714-225-7649	ZF 61-512-001	$ 73,000	DN 234 770	Other funding source
High Value Target Classification A. G. DiLoreto, Code 454 213-449-7561	ZF 61-512-001	12,000	DN 234 704	Completed
Hydrographic Winch Arrestor D. E. Good, Code 5044 714-225-6403	ZF 61-512-001	3,000	DN 234 707	Completed
Hull Vibration Generation and Detection for Acoustic Energy Transmission G. M. Coleman, Code 608 714-225-7505	ZF 61-512-001	9,000	DN 234 832	Completed
Incomplete Gaming Information J. T. Avery, Code 14 714-225-7721	ZF 61-512-001	7,000	DN 334 617	Completed
Investigation of the Influence of Vertical Beam Patterns and Source Frequency on Performance of Variable Depth Active Sonars J. R. Hooper, Code 6511 714-225-6377	ZF 61-512-001	5,000	Unavailable	Completed
Low Light Level Viewing System for Divers S. B. Bryant, Code 6511 714-225-6686	ZF 61-512-001	6,500	DN 234 616	Completed
New Electronic Concepts H. J. Whitehouse, Code 6003 714-225-6315	ZF 61-512-001	45,000	DN 234 872	Other funding source
Optical Visibility Instruments for Submersibles C. J. Funk, Code 6514 714-225-6686	ZF 61-512-001	0	DN 234 668	Funds discontinued

Project Title and Principal Investigator	Task Area	Fiscal Year 1973 Funding	Key to NARDIS Report	Reason for Termination
Preparation of Hydra II Support W. W. Perkins, Code 6543 714-225-6291	ZF 61-512-001	$ 0	DN 234 715	Completed
Remote Observation and Work Vehicle (SNOOPY) R. B. Fugitt, Code 6512 714-225-7629	ZF 61-512-001	0	DN 234 690	Merged into Small Unmanned Vehicles
Stable Platform Dynamics G. A. Wilkins, Code 6530 808-257-2161	ZF 61-512-001	25,000	DN 334 254	Completed
Submersible Cable Actuated Teleoperator (SCAT) J. L. Held, Code 6512 714-225-7629	ZF 61-512-001	0	DN 234 688	Merged into Small Unmanned Vehicles
Towed Fuel Pods for Semisubmerged Ships P. L. Warnshuis, Code 608 714-225-6497	ZF 61-512-001	0	DN 234 872	Completed
Underwater Communication Reverberation Reduction F. G. Geil, Code 0101 714-225-7455	ZF 61-512-001	2,000	DN 234 868	Completed
Underwater Thermal Power System Development S. K. Schultheis, Code 3521 213-449-7293	ZF 61-512-001	0	DN 234 766	Completed

publications

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publications

ARTICLES AND REPORTS

Burns, B., G.V. Pickwell. Cephalic Glands in Sea Snails (*Hydrophis, Laticauda, Pelamis*). *Journal Copeia*, Issue 3, September 1972.

Byram, G W., J. Alsup, J.M. Speiser, H.J. Whitehouse. Signal Processing Device Technology. *Proceedings of NATO Advanced Study Institute on Signal Processing, August 1972, Loughborough, UK*, IV-10

Leatherwood, J.S. Aerial Observations of Migrating Gray Whales *Eschrichtius robustus* off Southern California 1969-1972. *Proceedings of California Gray Whale Workshop, August 21-22, 1972. Fisheries Bulletin*, July 1973

Naval Undersea Center. Technical Publication 305, Effect of Bubble Inclusions on the Mechanical Properties of Cast Polymethyl Metacrylate, by J.D. Stachiw, August 1972.

Naval Undersea Center. Technical Publication 315, Acrylic Plastic Hemispherical Shells for NUC Undersea Elevator, by J.D. Stachiw. September 1972.

Naval Undersea Center. Technical Publication 324, Handbook of Dangerous Animals for Field Personnel, by G.V. Pickwell, W.E. Evans, eds. December 1972.

Naval Undersea Center. Technical Publication 325, Hydrodynamic Winch for Salvage Operations, by E.N Rosenberg December 1972.

Naval Undersea Center Technical Publication 345, Hydra 11A Comparison of High Explosive and Nuclear Underwater Explosions — A Summary, Analysis, and Evaluation of the HYDRA 11A Series, by W W. Perkins May 1972 SECRET

Naval Undersea Center Technical Publication 352, Experimental Study of Stochastic Ray Theory Relations, by J A Neubert, D E Edgars (In print)

Naval Undersea Center Technical Publication 359, Pull Down Retriever Unit, by E N Rosenberg, S F Moran (in print)

Patterson, C C., H V Weiss, M. Koide, E D Goldberg A Reply to a Technical Comment on Mercury and Lead in a Greenland Ice Sheet: A Reexamination of the Data *Science*, Vol 177 1972

Pickwell, G V The Venomous Sea Snakes *Fauna*, August 1972.

Salazar, M H Animal Attraction to Sunken Submarines *Oceans*, Vol 6, No. 3, May-June 1973.

Stachiw, J D Conical Acrylic Windows Under Long Term Hydrostatic Pressure of 5000 psi *Journal of Engineering for Industry/Transactions of ASME*, Vol 94, Series B, No 3, August 1972

Stachiw, J.D Conical Acrylic Windows Under Long Term Hydrostatic Pressure of 10,000 psi *Journal of Engineering for Industry/Transactions of ASME* Vol 94, Series B, No 4, November 1972

Stachiw, J D Effect of Bubble Inclusions on the Mechanical Properties of Cast Poly Methyl Metacrylate *Journal of Basic Engineering/Transactions ASME* Vol. 94, Series D, No 4, December 1972.

Stachiw, J D Effect of Temperature and Flange Support on Critical Pressure of Conical Acrylic Windows Under Short Term Pressure Loading *Journal of Basic Engineering/Transactions ASME*, Vol 94, Series D, No. 4, December 1972

U S Naval Civil Engineering Laboratory Report R-773 Windows for External or Internal Hydrostatic Pressure Vessels — Part VII — Effect of Temperature and Flange Configurations on Critical Pressure of 90 Degree Conical Acrylic Windows Under Short-Term Loading, by J D Stachiw, J R McKay, August 1972

Weiss, H V A Review of Lead, Sulfur, Selenium and Mercury in Permanent Snow Fields *Proceedings Symposium Marine Electrochemistry*, Miami Beach, Florida, 9-12 October 1972.

Weiss, H.V., K.K. Bertine. Simultaneous Determination of Manganese, Copper, Arsenic, Cadmium, Antimony and Mercury in Glacial Ice by Radioactivation. *Analytica Chimica Acta.* (In print).

Weiss, H.V., K. Chew. Neutron in Radiation of Mercury in Polyethylene Containers. *Analytica Chimica Acta.* (In print).

Williams, P.M., H.V. Weiss. Mercury in the Marine Environment: Concentration in Seawater and in a Pelagic Food Chain. *Journal of the Fisheries Research Board of Canada,* Vol. 30, 1973.

Young, R.W. Sound in Water from Aircraft. *Proceedings of the 29th Navy Symposium on Underwater Acoustics,* November 1972.

Young, R.W. Sound Pressure in Water from a Source in Air and Vice Versa. *Journal of the Acoustical Society of America,* Vol. 53, June 1973.

Zirino, A., S. Yamamoto. A pH-Dependent Model for the Chemical Speciation of Copper, Zinc, Cadmium, Lead, in Sea Water. *Limnology and Oceanography.* Vol. 17, No. 5, September 1972.

PRESENTATIONS

Hunt, J.T. Applications of the Finite Element Method and Computer Graphics. Proceedings of the Fourth Navy Nasa Structural Analysis Colloquium, Naval Ship Research and Development Center, Carderock, Md., 27 March 1973

Hunt, J.T. Finite Element Approach to Acoustic Radiation from Elastic Structures. Proceedings of the Fourth Navy Nasa Structural Analysis Colloquium, Naval Ship Research and Development Center, Carderock, Md., 27 March 1973

Johnson, C.S. Marine Animal Research at NUC. Marine Technology Society of San Diego, Ca., 24 May 1973

Marsh, W.H. Noise Field and Array Performance Comparison for the AN/BQR-7 on SSBN 619 and SSN 637. Conference on Bow Mounted Sonars, Naval Ship Research and Development Center, Md., 27 September 1972

Mattson, J.L. Simple Clinical Temperature Telemetry System for Pinnipeds. International Association for Aquatic Animal Medicine Conference, Vancouver, British Columbia, 31 May 1973.

McCool, J.M. Adaptive Systems Based on the LMS Algorithm. Technical Director's Symposium, Naval Undersea Center, San Diego, Ca., 27 June 1973

Neubert, J.A. Stochastic Eulerian-Lagrangian Approach to Wave Propagation. International Colloquium on the Theory and Applications of Stochastic Perturbation Techniques, Nice, France, September 1972

Pickwell, G.V. Pharmacological Properties of Sea Snake Venom. The Third International Food-Drugs from the Sea Symposium, University of Rhode Island, Rhode Island, 23-25 August 1972

Salazar, M.H. Environmental Impact of Sunken Target Hulls. Conference on the Environmental Effects of Explosives and Explosions. Naval Ordnance Laboratory, White Oak, Silver Springs, Md., 30-31 May 1973.

Schuthers, S.K. Portable Underwater Thermal Power System. US/UK Torpedo Propulsion Seminar, Admiralty Underwater Weapons Establishment, Portland, England, 13-15 February 1973. CONFIDENTIAL.

Stachiw, J.D. Acrylic Hemispheres for NUC Undersea Elevator. American Society of Mechanical Engineers, Paper 72-WH/Oct-4), Winter Annual Conference, 1972, New York, New York, 26-30 November 1972

Stachiw, J.D. Effect of Temperature and Flange Support on Critical Pressure of Conical Acrylic Windows Under Short Term Pressure Loading. American Society of Mechanical Engineers, Paper 72-OcT-8, Winter Annual Conference 1972, New York, New York, 26-30 November 1972

Stachiw, J.D., J. Maison. Flanged Acrylic Plastic Hemispherical Shells for Undersea Applications. American Society of Mechanical Engineers, Winter Annual Conference 1972, New York, New York, 26-30 November 1972.

Stachiw, J.D. Transparent Materials in the Sea. The Second International Ocean Development Conference, Tokyo, Japan, 4-9 October 1972.

Stachiw, J.D. Transparent Structural Materials for Ocean Engineering. Sigma Xi Society Lecture, Scranton University Chapter, Scranton, Pennsylvania, 29 November 1972.

Weiss, H.V. A Review of Lead, Sulfur, Selenium and Mercury in Permanent Snow Fields. Symposium on Marine Electrochemistry, Miami Beach, Fla., 10 October 1972.

Weiss, H.V. Certain Trace Elements in Permanent Snow Fields. Technical Director's Symposium, Naval Undersea Center, San Diego, Ca., 28 March 1973.

Weiss, H.V. Trace Elements in Permanent Snow Fields. Chemistry Department Seminar, California State University, San Diego, Ca., 23 February 1973.

PATENTS

Beaucher, G.V. Underwater Imaging System for Deep Submergence Vehicles. Navy Case 49,425.

Abstract: A quick release mounting apparatus for mounting a TV camera to a support. The mounting apparatus is especially useful for submerged operations since a diver can easily mount or remove the camera by moving one lever.

Benefit to the Navy: This invention enables a diver to quickly attach or disengage a camera from an underwater tripod.

Clinkenbeard, J.D. Messenger Buoy Recovery Device. Navy Case 49,430.

Abstract: This invention includes a hollow spool, a lift cable, and a float which can be attached by a diver to a submerged object.

Benefit to the Navy: Location and retrieval of instrumentation packages is greatly facilitated by this invention.

Fugitt, R.B. Instrument for Measuring the Depolarization of Backscattered Light. Navy Case 50,542.

Abstract: This invention is a small, compact, instrument which can measure the degree that polarized light is depolarized when reflected from a target located in an area where much backscattering is present.

Benefit to the Navy: Instrument permits Navy divers to measure amount of backscattered light, always present with artificial illumination, permitting adoption of polarization for underwater viewing.

Gill, G.H. Direct Current Motor Starter Circuit. Navy Case 53,672.

Abstract: An improved starting circuit for DC motors conserves battery life for small submersibles.

Benefit to the Navy: Improved battery life and operational safety are benefits to the Navy.

Gill, G.H. Carbon Dioxide Indicating Meter. Navy Case 51,291.

Abstract: The present invention is directed to providing a meter for indicating the concentration of CO_2.

Benefit to the Navy: This invention reduced the hazard of carbon dioxide build-up in submersibles.

Heckman, P.J. Cable-Less Television System. Navy Case 49,173.

Abstract: This invention relates to an apparatus for surveillance of a distant target from a remote viewing point which does not require a cable or the transmission of acoustic signals between the target and the viewing point.

Benefit to the Navy: Future development of small Navy submersibles will incorporate this system.

Hirsch, J. Energy Absorption Apparatus. Navy Case 51,981.

Abstract: An energy absorption device is utilized to absorb the high energy loading due to a missile being launched with a retarding parachute. The device includes an enlarged bulb shaped mandrel, a die, and a soft metallic sleeve. When the mandrel is pulled through the soft metallic sleeve, the sleeve is extruded through the die to absorb the energy due to the high loading.

Benefit to the Navy: This invention provides a simple but highly efficient and reliable energy absorption device for absorbing energy for parachute launched rockets or torpedoes.

Johnson, C.S., A.F. Langguth. Full View Diver's Mask. Navy Case 53,724.

Abstract: An improved full view diver's mask provides distortion-free vision over an angle in excess of 180°.

Benefit to the Navy: This invention increases a diver's ability to perform his undersea task successfully.

Johnson, C.S., A.F. Langguth. Method of Making a Protective Diving Suit. Navy Case 53,467.

Abstract: A protective diving suit for a diver resists puncture by sharp objects and animal bites and is not compressed at depth to provide insulation and warmth.

Benefit to the Navy: A greater degree of diver safety is afforded by this diving suit to reduce the threat imposed by marine predators.

Johnson, C.S., A.F. Langguth. Anti-Shark Drogue Dart. Navy Case 52,376.

Abstract: This invention is a device for reducing the threat imposed by a menacing shark. After a sharpened dart has been embedded at long range in the shark, an attached small drogue chute creates an asymmetrical drag. This drag upsets the shark's hydrodynamic equilibrium and prevents its swimming in a coordinated manner.

Benefit to the Navy: Divers can perform their tasks more effectively when hostile sharks are neutralized with this invention.

Karp, R.E. High Speed Fail Safe Weapon Retarding System. Navy Case 46,618.

Abstract: This invention is an improved parachute system for retarding the speed of a missile which has just been launched from an aircraft.

Benefit to the Navy: This invention provides safety to aircraft launching a parachute retarded torpedo by deploying a small parachute prior to displaying the main parachute.

Lang, T.G. High Speed Ship with Submerged Hull. Navy Case 54,407.

Abstract: A high speed ship is formed of at least one elongate hull section submerged completely beneath the water's surface supporting a platform above the surface waves by a plurality of struts dependent from the platform. High speed dynamic pitch stability is ensured by including a stabilizer member on the aft portion of the submerged hull to provide a highly-stable cargo-transport capability as well as a superior weapons platform.

Benefit to the Navy: This invention serves as a basis for development of an advanced type surface ship.

Lemaire, I.P. Underwater Imaging System for Deep Submergence Vehicles. Navy Case 49,005.

Abstract: This invention is an imaging system for a deep submergence vehicle. The invention is particularly useful for viewing or mapping the ocean bottom with a minimum of backscattering.

Benefit to the Navy: By improving the undersea imaging deep submergence operations, more reliable data can be obtained.

Lindsay, G.F., S.F. Sullivan, H.J. Whitehouse. Correlators Using Shift Registers. Navy Case 47,874.

Abstract: This invention relates to a correlator comprising a set of multivibrators which are serially connected to form a shift register, each multivibrator having a set and reset output lead, indicating its binary state. The input multivibrator, is connectable to a source of signals, generally bilevel signals or pulses. Means are operatively connected to the output leads of the multivibrators for summing the outputs of the multivibrators for each shift of binary states, the sum being a maximum for a particular combination, or coding, of binary states of the multivibrators of the shift register.

Benefit to the Navy: Because huge amounts of data are processed annually by the Navy, a device such as this invention which expedites data processing is of considerable benefit.

Lindsay, G.F., H.J. Whitehouse. Field-Delineated Acoustic Wave Device. Navy Case 49,426.

Abstract: An acoustic wave device has a substrate capable of propagating an acoustic wave and a conductive structure defining several conductive paths. Field-delineating electrodes interleave electrodes disposed along the paths.

Benefit to the Navy: This invention serves as a basis for continuing development.

Lopes, L.A., O.F. Thomas. Digital Camera. Navy Case 50,070.

Abstract: This invention relates to a camera which utilizes digital input signals to enable it to form sharper pictures or patterns of an object.

Benefit to the Navy: The camera is able to distinguish between objects of the same size but different profiles, such as a whale and a submarine of the same size.

Lopes, L.A. Strapped-Down Attitude Reference System. Navy Case 50,019.

Abstract: The invention provides an attitude reference for vehicles in the earth's gravitational field, such as aircraft, tanks, submarines, and torpedoes.

Benefit to the Navy: The system is particularly useful for vehicles in the earth's gravitational field, where the reference provided by gravity is lost because of the vehicle's acceleration.

Rosenberg, E.N. Hydrodynamic Transducer. Navy Case 51,377.

Abstract: An acoustic transducer employs a pump drawing in ambient water and impelling it through a rotating slotted shutter. This transducer, being flooded, is non-responsive to ambient pressure changes to provide uniform broadband operational characteristics irrespective of depth.

Benefit to the Navy: The Navy could utilize this invention in deep submergence sonar applications.

Sayre, J.L. Claw Arms with Swivel Plate. Navy Case 51,906.

Abstract: A claw assembly has a pair of arms for retrieving conical objects. One arm is capable of engaging a circumference of the conical object and a swivel plate on the other arm is capable of pivoting to engage a tapered portion of the object.

Benefit to the Navy: Retrieval of training ordnance is enhanced at a considerable savings to the Navy.

Speiser, J.M., H.J. Whitehouse. Surface Wave Multiplex Transducer Device with Gain and Side Lobe Suppression. Navy Case 51,706.

Abstract: A surface-wave multiplex device has a number of launch-vertical stacks of transducers and a corresponding number of the same plurality of receive-vertical stacks of transducers to reduce, by a factor of 2, the number of information paths.

Benefit to the Navy: Permits compact signal processing of continued signals.

Strapp, J.P., N.E. Cornford. Apparatus for Determining the Presence of a Vessel by Detecting its Wake. Navy Case 49,787.

Abstract: This invention relates to apparatus for determining the presence of a vessel, such as a submarine, by detecting its wake.

Benefit to the Navy: Further investigation is being pursued because of the Navy's strong interest in improving ASW capability.

Strapp, J.P. Homing System for the Acquisition of a Sea-Going Target Vehicle by Detection of its Wake. Navy Case 49,788.

Abstract: A missile homing system uses pairs of thermocouple junctions for the acquisition of a sea-going target vehicle by detection of its wake.

Benefit to the Navy: This invention provides a basis for development of a future detection system.

Strickland, A.T. Variable Buoyancy Control System. Navy Case 53,220.

Abstract: The present invention provides an automatic buoyancy control for a deep submersible. As the deep submersible ascends or descends the invention automatically pressure balances the buoyancy tank. In this manner the tank can be constructed of thinner walls and precise ballasting and deballasting can be accomplished.

Benefit to the Navy: The benefit to the Navy is an improved underwater transport vehicle for use by Navy divers.

Whitehouse, H.J. Surface Wave Devices for Signal Processing. Navy Case 52,524.

Abstract: The invention relates to distributed-transducer surface wave devices which process input acoustic surface waves. In one embodiment, the device time-compresses and recirculates input signals, thereby serving as a memory and making the information available when required.

Benefit to the Navy: The device permits compact processing for digital data.

Whitehouse, H.J. Surface Wave Ambiguity Analyzer. Navy Case 50,629.

Abstract: A surface wave ambiguity analyzer having no moving parts is used for detecting radar or sonar signals.

Benefit to the Navy: Permits determining wide beam signal ambiguity of radar or sonar signals.

Wilson, W.G., J.H. Green, W.D. White. Snap Acting Ballast Release Device. Navy Case 42,207.

Abstract: The present invention is a weight device which is recessed within an exercise torpedo. After the torpedo has made its run, the weight device is released and the torpedo is buoyed toward the water's surface for recovery.

Benefit to the Navy: This invention provides a ballast release device for a practice torpedo. The ballast snaps away from the torpedo so that there is no interference with ascension of the torpedo.